KEITHLEY

Model 263 Calibrator/Source
Instruction Manual

A GREATER MEASURE OF CONFIDENCE

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Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are rated Installation Category I and Installation Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Installation Category I and must not be directly connected to mains voltage or to voltage sources with high transient over-voltages. Installation Category II connections require protection for high transient over-voltages often associated with local AC mains connections. The user should assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the Manual.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

263 Calibrator/Source

AMPS V/R (Passive)

RANGE	STEP SIZE	ACCURACY[1] ±(% setting + offset) 18°–28°C 90 Days	ACCURACY[1] ±(% setting + offset) 18°–28°C 1 Year	TEMPERATURE COEFFICIENT ±(% setting + offset)/°C 0°–18°C & 28°–50°C	OUTPUT RESISTANCE
2 pA	50 aA	0.375 + 10 fA	0.425 + 10 fA	0.04 + 2 fA	100 GΩ
20 pA	500 aA	0.325 + 10 fA	0.375 + 10 fA	0.04 + 2 fA	100 GΩ
200 pA	5 fA	0.20 + 30 fA	0.25 + 30 fA	0.01 + 2 fA	10 GΩ
2 nA	50 fA	0.0625 + 100 fA	0.065 + 100 fA	0.01 + 30 fA	1 GΩ
20 nA	500 fA	0.0625 + 1 pA	0.065 + 1 pA	0.0035 + 100 fA	100 MΩ
200 nA	5 pA	0.035 + 10 pA	0.035 + 10 pA	0.0025 + 1 pA	10 MΩ
2 µA	50 pA	0.025 + 100 pA	0.025 + 100 pA	0.0025 + 10 pA	1 MΩ
20 µA	500 pA	0.025 + 1 nA	0.025 + 1 nA	0.0025 + 100 pA	100 kΩ
200 µA	5 nA	0.025 + 10 nA	0.025 + 10 nA	0.0025 + 1 nA	10 kΩ
2 mA	50 nA	0.025 + 100 nA	0.025 + 100 nA	0.0025 + 10 nA	10 kΩ
20 mA	500 nA	0.15 + 1 µA	0.15 + 1 µA	0.0025 + 100 nA	1 kΩ

[1] Assumes <100µV compliance (voltage burden).

COULOMBS V/R (Passive)

RANGE	STEP SIZE	ACCURACY[1] ±(%setting+offset) 18°–28°C 1 Year	TEMPERATURE COEFFICIENT ±(% setting+offset)/°C 0°–18°C & 28°–50°C	OUTPUT RESISTANCE
20 pC	0.5 fC	1.0 + 50 fC	0.05 + 10 fC	100 GΩ
200 pC	5 fC	0.5 + 75 fC	0.01 + 10 fC	10 GΩ
2 nC	50 fC	0.1 + 300 fC	0.01 + 10 fC	1 GΩ
20 nC	500 fC	0.1 + 3 pC	0.01 + 100 fC	100 MΩ
200 nC	5 pC	0.5 + 30 pC	0.01 + 1 pC	10 MΩ
2 µC	50 pC	0.5 + 300 pC	0.01 + 10 pC	1 MΩ
20 µC	500 pC	0.5 + 3 nC	0.01 + 100 pC	100 kΩ

[1] Measurement interval is 2.5 seconds. Assumes <100µV of compliance (voltage burden).

COULOMBS (Active)

Accuracy is the same as COULOMBS V/R except change the offset to 300fC on the 20pC and 200pC ranges.

VOLTS

RANGE	STEP SIZE	90 Days	ACCURACY[1] ±(%setting+offset) 18°–28°C 1 Year	TEMPERATURE COEFFICIENT ±(% setting + offset)/°C 0°–18°C & 28°–50°C
200 mV	5 µV	0.0125 + 15 µV	0.0175 + 15 µV	0.002 + 0.5 µV
2 V	50 µV	0.0125 + 50 µV	0.0175 + 50 µV	0.002 + 2 µV
20 V	500 µV	0.0125 + 500 µV	0.0175 + 500 µV	0.002 + 20 µV

[1]Load resistance >100kΩ.

RESPONSE TIME: <0.5 second to rated accuracy.

OUTPUT RESISTANCE: <1Ω.

SHORT CIRCUIT CURRENT LIMIT: <75mA.

NOISE: <25ppm of range peak to peak in a 0.1Hz to 10Hz bandwidth.

IEEE-488 BUS IMPLEMENTATION

MULTILINE COMMANDS: DCL, LLO, SDC, UNL, UNT, GTL.

UNILINE COMMANDS: REN, ATN, EOI, IFC, SRQ.

INTERFACE FUNCTIONS: SH1, AH1, T6, TE0, L4, LE0, SR1, RL0, PP0, DC1, DT0, C0, E1.

PROGRAMMABLE PARAMETERS: Function, Range, Value, Zero, Operate, Guard, Digital Calibration, Temperature Compensation, Terminator, Status, Data Format, SRQ.

Specifications subject to change without notice.

AMPS (Active)

Accuracy is the same as V/R, except change % setting on the 20mA range to 0.035% and change the offsets per the following table:

RANGE	ACCURACY ± offset	TEMPERATURE COEFFICIENT ± offset/°C
2 pA	100 fA	30 fA
20 pA	100 fA	30 fA
200 pA	120 fA	30 fA
2 nA	200 fA	No change

OUTPUT RESISTANCE: $>10^{14}\Omega$ on 2nA range and above.

OUTPUT CAPACITANCE: <50pF.

OUTPUT LOAD: Output load must be non-inductive.

COMPLIANCE VOLTAGE: >12V. Front panel OPERATE light flashes when compliance is reached.

MAXIMUM OPEN CIRCUIT VOLTAGE: <45V for the 2mA and 20mA ranges; <25V for the 2pA–200µA ranges.

RESPONSE TIME: <0.5 second to rated accuracy for the 2nA–20mA ranges; <5 seconds for the 2pA–200pA ranges.

PREAMP OUTPUT: Maximum Load Current: 5mA.

Maximum Load Capacitance: 10nF.

OHMS

NOMINAL VALUE	ACCURACY ±(% setting) 18°–28°C 90 Days	ACCURACY ±(% setting) 18°–28°C 1 Year	TEMPERATURE COEFFICIENT ±(% setting/°C) 0°–18°C & 28°–50°C
1 kΩ	0.04[1]	0.04[1]	0.0005
10 kΩ	0.02[1]	0.02[1]	0.0005
100 kΩ	0.02	0.02	0.0005
1 MΩ	0.025	0.025	0.0005
10 MΩ	0.035	0.0375	0.0015
100 MΩ	0.065	0.07	0.0015
1 GΩ	0.08	0.10	0.008[2]
10 GΩ	0.20	0.225	0.008[2]
100 GΩ	0.375	0.40	0.04[2]

[1] After subtracting ZERO offset.

[2] Displayed value corrected for resistor temperature coefficient.

ZERO OFFSET: <1Ω.

TOLERANCE OF NOMINAL VALUE: 1kΩ–1MΩ, 0.1%; 10MΩ, 0.2%; 100MΩ–100GΩ, 3%.

MAXIMUM VOLTAGE ACROSS RESISTANCE FOR RATED ACCURACY: 1kΩ–10GΩ, 20V; 100GΩ, 100V.

GENERAL

DISPLAY: 5½-digit numeric LEDs with appropriate decimal point and polarity indication; signed two-digit alphanumeric exponent.

OUTPUT CONNECTIONS: Two-lug triaxial connector for output; five-way binding posts for PREAMP OUT, COMMON, and EXT INPUT. All connections on rear panel.

PROGRAMS: Menu provides front panel access to IEEE-488 address, Alpha or Numeric Exponent, Digital Calibration, and Temperature Compensation selection.

MAX. COMMON MODE VOLTAGE (DC to 60Hz sinewave): 350V peak.

ISOLATION (Common to Chassis): $>10^{10}\Omega$ paralleled by <500pF.

EXT INPUT: Max. Input: 200V peak, 100mA peak.
Series Resistance: <1Ω.

WARM-UP: 1 hour to rated accuracy.

ENVIRONMENT: Operating: 0°–50°C; <70% RH non-condensing up to 35°C. **Storage:** –25° to +60°C.

POWER: 105–125V or 210–250V (rear panel switch selected), 90–110V available, 50–60Hz, 25VA maximum.

DIMENSIONS, WEIGHT: 127mm high × 216mm wide × 359mm deep (5 in × 8½ in × 14⅛ in). Net weight 3.6kg (8.1 lbs).

ACCESSORY SUPPLIED: Model 7024-3 Triax Cable, instruction manual.

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SECTION 1
General Information

1.1 INTRODUCTION

This section contains information on the Model 263 Calibrator/Source features, warranty, manual addenda, specifications, and safety terms and symbols. Also included are procedures for unpacking and inspecting the instrument, as well as a brief description of available accessories.

The information in Section 1 is arranged as follows:

1.2 **Features**
1.3 **Warranty Information**
1.4 **Manual Addenda**
1.5 **Safety Symbols and Terms**
1.6 **Specifications**
1.7 **Unpacking and Inspection**
1.8 **Repacking for Shipment**
1.9 **Optional Accessories**

1.2 FEATURES

- Resistance sourcing from 1kΩ to 100GΩ in decade steps.
- DC voltage sourcing from 0V to ±19.9995V.
- DC current sourcing from 0A to ±19.9995mA.
- DC charge sourcing from 0C to ±19.9995μC.
- Temperature compensation for the 1GΩ, 10GΩ and 100GΩ resistors. This feature allows the unit to track the actual resistance of these resistors as the ambient temperature changes.
- Two methods of data entry. The keypad method uses front panel buttons configured as a standard keypad to enter output readings on the display. The adjust method uses two adjust buttons to increment or decrement the displayed reading.
- Zero at the touch of a button. The ZERO button toggles the display between zero and the programmed output reading.
- Fully programmable over the IEEE-488 bus.
- Simple calibration: A single Keithley Model 196 DMM (or equivalent) is the only instrument needed.

1.3 WARRANTY INFORMATION

Warranty information for your Model 263 may be found inside the front cover of this manual. Should it become necessary for you to use the warranty, contact your Keithley representative or the factory for information on obtaining warranty service. Keithley Instruments, Inc maintains service facilities in the United States, West Germany, France, the Netherlands, Switzerland and Austria. Information concerning the operation, application, or service of your instrument may be directed to the applications engineer at one of these locations.

1.4 MANUAL ADDENDA

Information concerning changes or improvements to the instrument which occur after this manual has been printed will be found on an addendum sheet included with the instrument. Please be sure to read this information before attempting to operate or service the instrument.

1.5 SAFETY TERMS AND SYMBOLS

The following safety terms are used in this manual or found on the instrument.

The symbol ⚠ on the instrument indicates that the user should refer to the operating instructions in this manual for further details.

The **WARNING** heading used in this manual explains dangers that could result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

1.6 SPECIFICATIONS

Detailed Model 263 specifications are located at the front of this manual.

1.7 UNPACKING AND INSPECTION

The Model 263 was carefully inspected and packed before shipment. Upon receiving the instrument, carefully unpack all items from the shipping carton and inspect for any obvious signs of damage that might have occurred during shipment. Report any damage to the shipping agent immediately. Retain the original packing material in case reshipment becomes necessary.

1.7.1 Shipment Contents

The following items are included with every Model 263 shipment:

Model 263 Calibrator/Source
Model 7024-3 Triax to Traix Cable (3 ft.)
Instruction Manual
Quick Reference Guide

1.7.2 Additional Documentation

If an additional instruction manual is required, order the manual package, Keithley Part Number 263-901-00. The manual package includes an instruction manual and all pertinent addenda.

If an additional Quick Reference Guide is required, order Keithley Part Number 263-903-00.

1.8 REPACKING FOR SHIPMENT

Before shipment, the unit should be carefully packed in its original packing carton using all original packing materials.

If the instrument is to be returned to Keithley Instruments for repair, complete the following:

1. On the shipping label, indicate the warranty status of the instrument and write;

   ATTENTION REPAIR DEPARTMENT

2. Complete and include the service form at the back of this manual.

1.9 OPTIONAL ACCESSORIES

The following accessories for the Model 263 are available from Keithley Instruments, Inc. Contact your Keithley representative or the factory for information on obtaining these accessories.

Models 1019A-1 and 1019A-2 are fixed shelf-type rack mounting kits for half-rack, 127mm (5½ in.) high instruments (such as the Model 263). The 1019A-1 kit mounts one instrument and the 1019A-2 mounts two.

Models 1019S-1 and 1019S-2 are sliding shelf-type mounting kits for half-rack, 127mm (5½ in.) high instruments (such as the Model 263). The 1019S-1 kit mounts one instrument and the 1019S-2 mounts two.

Model 4804 is a 2-slot male BNC to 2-lug female triaxial adapter. Used to adapt the supplied triaxial output cable of the Model 263 to 2-lug BNC input connectors.

Models 6011 and 6011-10 Trixial Cables are made up of three feet of triaxial cable that is terminated with a triax plug on one end and three alligator clips on the other end. The Model 6011-10 is a similar cable 10 feet in length.

Model 6012 Triax to UHF Adapter allows the Model 263 to be used with accessories having UHF type connectors.

Model 6105 Resistivity Chamber is a guarded test fixture for measuring voltage and surface resistivities. The unit assures good electrostatic shielding and high insulation resistance. The complete system requires the use of an external voltage supply such as the Model 263 as well as a picoammeter. Volume resistivity up to $10^{9}\Omega$/cm and surface resistivity up to $10^{18}\Omega$ can be measured in accordance with ASTM test procedures. Sheet samples 64 to 102mm (2½ × 4″) in diameter and up to 6.4mm (¼″) thickness can be accommodated. Excitation voltages up to 1000V may be used.

Model 6146 Triax Tee Adapter allows the simultaneous connection of two triaxial cables to the single triaxial output of the Model 263.

Model 6147 Triax to BNC Adapter allows the Model 263 output to be connected to accessories having BNC connectors.

Model 6167 Guarded Input Adapter is used to reduce effective cable capacity by driving the inner shield of the triaxial cable at guard potential. Use to make guarded connections from the Model 263 to Keithley Models 602, 614 and 6161 Electrometers. Triax female to triax male.

Models 6171 and 6172 3-Lug to 2-Lug Adapters—The Model 6171 is a 3-lug male to 2-lug female triaxial adapter, while the Model 6172 is a 2-lug male to 3-lug female triaxial adapter.

Model 6191 Guarded Input Adapter is similar to the Model 6167 except it is used to make guarded connections from the Model 263 to the Model 619 Electrometer. Triax female to triax male.

Models 7007-1 and 7007-2 are shielded IEEE-488 interface cables with shielded connectors on each end. The 7007-1 is 1m (3.3 ft.) in length and the 7007-2 is 2m (6 ft.) in length.

Model 7010 Shielded IEEE to IEEE Adapter provides additional clearance between the IEEE-488 cable and rear panel, allowing easier access to switches, cables, and other connectors.

Model 7023 Female Triaxial Connector is a chassis mount connector that mates with the Models 6011 and 7024 triaxial cables.

Models 7024-3 and 7024-10 are triaxial cables terminated with 2-lug male triaxial connectors on each end. The 7024 is 0.9m (3 ft.) in length and the 7024-10 is 3.0m (10 ft.) in length.

SECTION 2
Getting Started

2.1 INTRODUCTION

This section contains introductory information on operating your instrument and is intended to help you get your Model 263 up and running as quickly as possible. It includes a brief description of operating controls and test connections. Once you are familiar with the material presented here, refer to Section 3 for more detailed information.

Section 2 is organized as follows:

2.2 **Front Panel Familiarization:** Briefly describes each front panel control, outlines display operation, and lists where to find more detailed information in Section 3.

2.3 **Rear Panel Familiarization:** Outlines each aspect of the Model 263 rear panel including connectors and switches.

2.4 **Basic Sourcing Techniques:** Provides a general step-by-step procedure for sourcing resistance, voltage, current and charge.

2.2 FRONT PANEL FAMILIARIZATION

An overview of the Model 263 is given in the following paragraphs. The front panel of the instrument is shown in Figure 2-1, along with a brief description of each item.

All front panel controls except POWER are momentary contact switches. Some control buttons have an annunicator light to indicate the selected function. Some buttons have a secondary function that may be entered by pressing first SHIFT and then the desired button. All such secondary functions are marked in yellow as is the SHIFT button. The controls are color-coded into functional groups for ease of operation.

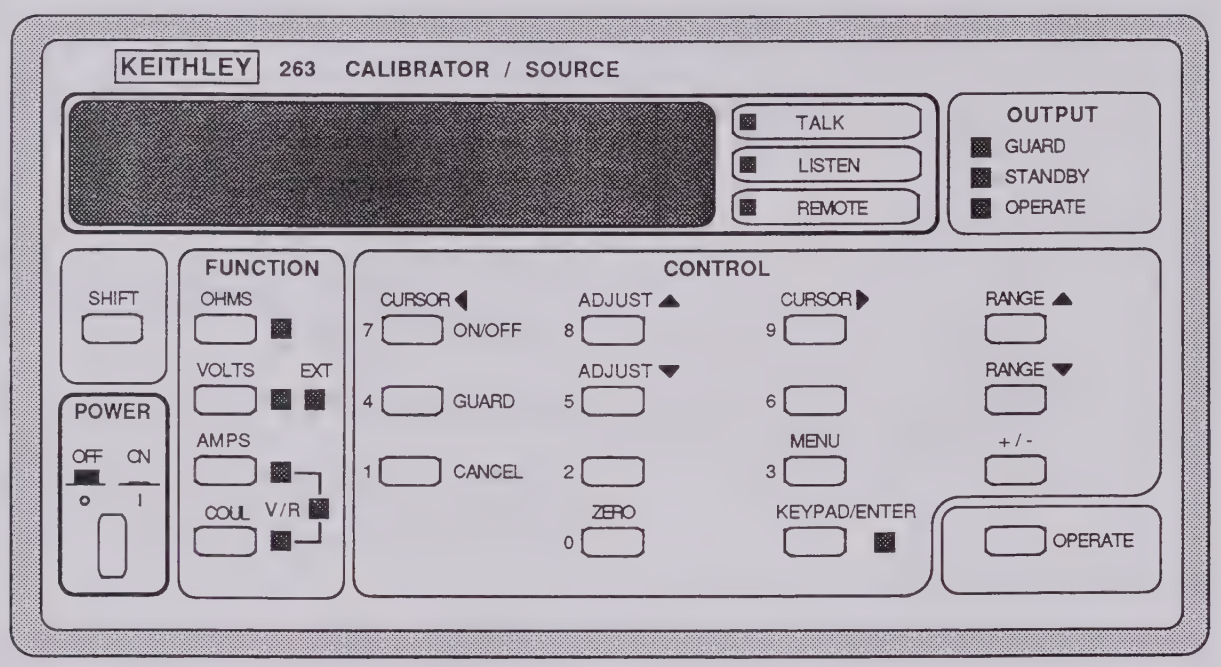


Figure 2-1. Model 263 Front Panel

POWER AC power switch turns unit on or off.

SHIFT Enables access to secondary features (highlighted in yellow).

FUNCTION BLOCK

OHMS Configures the Model 263 to source 1kΩ to 100GΩ.

VOLTS Configures the Model 263 to source zero to ±19.9995V.

SHIFT VOLTS Configures the Model 263 to output an external source applied to the rear panel EXT INPUT of up to ±200V peak.

AMPS Configures the Model 263 as an active current source that can output zero to ±19.9995mA.

SHIFT AMPS Configures the Model 263 as a passive current source (AMPS V/R) that can output zero to ±19.9995mA.

COUL Configures the Model 263 as an active coulomb source that can output zero to ±199.995μC.

SHIFT COUL Configures the Model 263 as a passive coulomb source (COUL V/R) that can output zero to ±199.995μC.

CONTROL BLOCK

RANGE These two buttons are used to select the range of the selected function. RANGE ▲ upranges the instrument, while RANGE ▼ downranges.

CURSOR These two buttons along with the adjust buttons provide one method (Adjust Method) to enter numeric data on the display. With the cursor off (see SHIFT ON/OFF), each press of a cursor button identifies the currently selected display digit by momentarily flashing a digit segment. With the cursor on, a segment of the selected digit flashes continuously. CURSOR ◄ moves the cursor from right to left and CURSOR ► moves the cursor from left to right.

SHIFT ON/OFF Toggles cursor on and off.

ADJUST ADJUST ▲ increments the display at the currently selected digit, while ADJUST ▼ decrements the display. For example, on the 1V range with the cursor at the tenths digit, each momentary press of an ADJUST button will increment or decrement the display reading by 0.1V. The ADJUST buttons are also used to change front panel program parameters. The ADJUST buttons are inoperative in the ohms function.

KEYPAD/ENTER This button along with the number buttons provide another method (Keypad Method) to enter numeric data on the display. The display reading can be changed on all functions except ohms. When the keypad is enabled the cursor will be at the most significant digit. After a number is keyed in at the most significant digit position, the remaining digits will zero and the cursor will move to the next less significant digit. After keying in the desired display reading, press ENTER to enter the new reading and disable the keypad. The ohms display reading cannot be altered by the keypad.

SHIFT CANCEL Operational only when KEYPAD is enabled. Pressing SHIFT CANCEL after keying in a reading using the keyboard will cancel that reading and disable the keyboard. The display will return to the previous reading before KEYPAD was enabled.

± Toggles the display between positive (+) polarity and negative (−) polarity.

ZERO This button toggles the display between zero and the reading that was previously displayed.

SHIFT GUARD Toggles the output configuration between guarded and unguarded. A simplified schematic of the guard circuitry is located on on the rear panel.

MENU Scrolls through the available front panel programs. With a program displayed, the parameters can be changed with the ADJUST buttons. Scrolling past the last program returns the display to the normal mode.

OPERATE Toggles the instrument between the standby and operate conditions. In operate, the programmed source is available at the output.

IEEE STATUS INDICATORS

TALK, LISTEN, REMOTE These three indicators apply to instrument operation over the IEEE-488 bus. The REMOTE indicator shows when the instrument is in the IEEE-488 remote state. The TALK and LISTEN indicators show when the instrument is in the talk and listen states respectively. See Section 4 for detailed infomation on operation over the bus.

2.3 REAR PANEL FAMILIARIZATION

An overview of the rear panel of the Model 263 is provided in the following paragraphs. The rear panel is shown in Figure 2-2. In addition to the various connectors and switches, a simplified schematic of the guard circuitry is provided. Also included is a cross reference to other sections of the manual where more detailed information can be found.

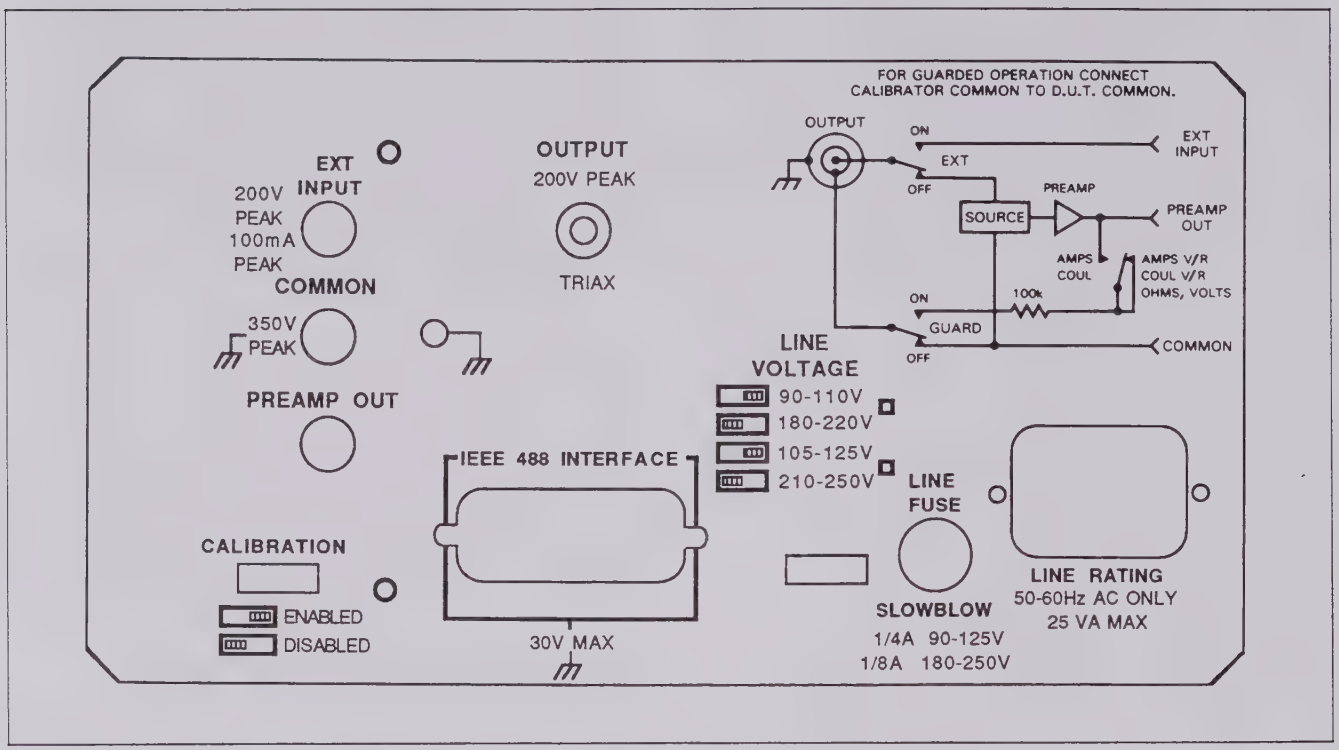


Figure 2-2. Model 263 Rear Panel

OUTPUT The source output high is available at this triax connector. Source low may also be available here or at the COMMON terminal depending on the configuration of the output.

EXT INPUT This banana plug is used to connect an external supply (up to ±200mA) to the Model 263. This external supply is then available at the output of the Model 263 when VOLTS EXT is selected.

COMMON Source output low is always available at this terminal regardless of the configuration of the output.

PREAMP OUT This terminal along with the COMMON terminal can be used to monitor the voltage drop across a load when the instrument is sourcing current or charge. This terminal can also be used as an external guard source when sourcing AMPS or COUL. PREAMP OUT is inoperative in AMPS V/R, COUL V/R, VOLTS, and OHMS.

CALIBRATION Switch Permanent calibration of the Model 263 can only be done if the CALIBRATION switch is in the ENABLED position.

IEEE CONNECTOR This connector is used to connect the instrument to the IEEE-488 bus. IEEE interface functions are marked above the connector.

LINE VOLTAGE This switch is used to match the instrument to the available line voltage.

LINE FUSE The line fuse provides protection for the AC power line input. The fuse rating must match the line voltage setting.

AC RECEPTACLE Power is applied through the supplied power cord to the 3-terminal AC receptacle.

2.4 CALIBRATOR/SOURCE OPERATION

The following paragraphs will take you through a simple, general, step-by-step procedure to source resistance, voltage, current or charge. The Model 263 can be used to calibrate electrometers and picoammeters, or as a precision source to a load. The following procedure uses a four-function electrometer (Keithley Model 617) to demonstrate operation. However, any suitable load or electrometer can be used instead. Using a four-function electrometer for this demonstration simplifies the procedure and allows the user to measure the actual output of the Model 263. If a suitable electrometer is not available at this time, performing the procedure with an open output will still have instructional benefit.

2.4.1 Power Up

Check that the instrument is set to correspond to the available line voltage. The line voltage switch is located on the rear panel. If the switch is set to the correct position, connect the instrument to a grounded AC outlet using the supplied power cable and turn on the instrument.

CAUTION

If the switch setting does not correspond to the available line power, do not change the switch setting and power up the instrument as the line fuse will probably blow. Instead, proceed to pargagraph 3.2 for the complete power up procedure.

The instrument can be used immediately, however, a one hour warm up period is required to achieve rated accuracy.

2.4.2 Test Connections

For the following procedures, simply connect the output of the Model 263 to the input of the Model 617 Electrometer using the supplied triax cable.

2.4.3 Basic Sourcing Procedure

Configure the Model 617 Electrometer to make unguarded resistance, voltage, current or coulomb measurements, and select autorange. Perform the following steps to demonstrate the basic sourcing procedure.

Step 1: Select Function

Press the appropriate FUNCTION button (OHMS, VOLTS, AMPS, or COUL). The Model 263 will display the power up default setting of the selected function. For all functions, except ohms, the display will read zero. On ohms, the actual value of the 1kΩ resistor will be displayed.

Step 2: Select Range

In general, RANGE ▲ upranges the instrument and RANGE ▼ downranges the instrument.

Step 3: Program Output

There are two methods to set the display to the desired output reading; the Adjust method and the Keypad method. Try both methods.

Note: OHMS readings cannot be altered since they are fixed resistors.

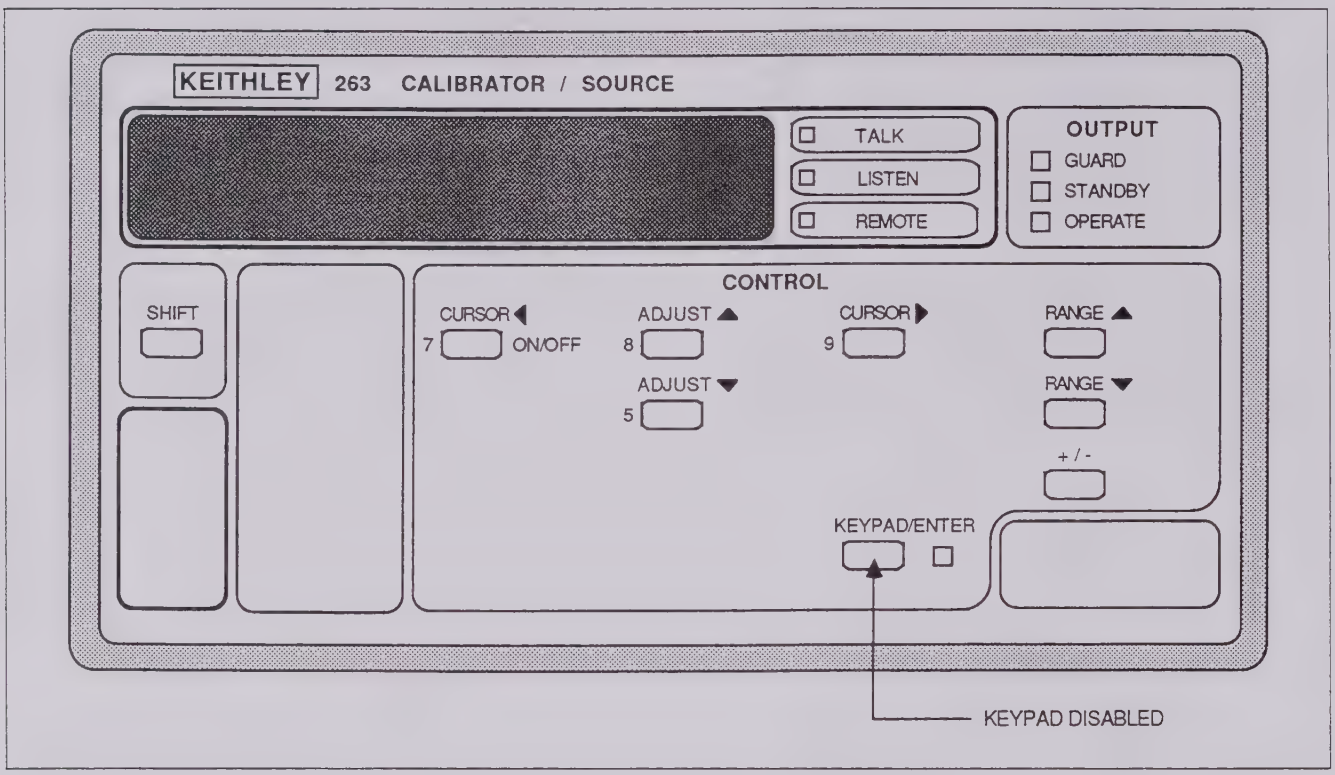


Figure 2-3. Data Entry Controls - Adjust Method

Adjust Method:

(Refer to Figure 2-3.)

1. Position Cursor - Each momentary press of a CURSOR button shows the position of the cursor by briefly flashing a digit segment on and off. To continuously display the cursor position, press SHIFT ON/OFF. Position the cursor on the digit to be changed using the CURSOR ◄ and CURSOR ► buttons.
2. Adjust Display Reading - Use the ADJUST ▲ button to increase the reading and ADJUST ▼ to decrease the reading. Each momentary press of an ADJUST button increments or decrements the reading by one unit (value is determined by range and cursor position). Polarity of the reading can be changed at any time by pressing the ± button.

Keypad Method:

(Refer to Figure 2-4.)

1. Enable Keypad - Press the KEYPAD/ENTER button to enable the keypad. The keypad indicator light will turn on.
2. Key In Reading - With the cursor positioned at the most significant digit, key in the desired number by pressing the appropriate number button (0 through 9). The rest of the display digits will zero and the cursor will move to the next less significant digit. Key in as many numbers as necessary.

   Note: If it is desired to cancel the keyed in reading and return to the reading that was displayed before keypad was enabled, press SHIFT CANCEL. The keypad will disable.
3. Enter Reading - With the desired reading displayed, again press KEYPAD/ENTER. The new reading will be entered and the keypad will disable.

Step 4: Go To Operate

To source the programmed parameter to the electrometer, press the OPERATE button. The STANDBY indicator light will turn off and the OPERATE indicator light will turn on. Note that range changes can be made while in OPERATE.

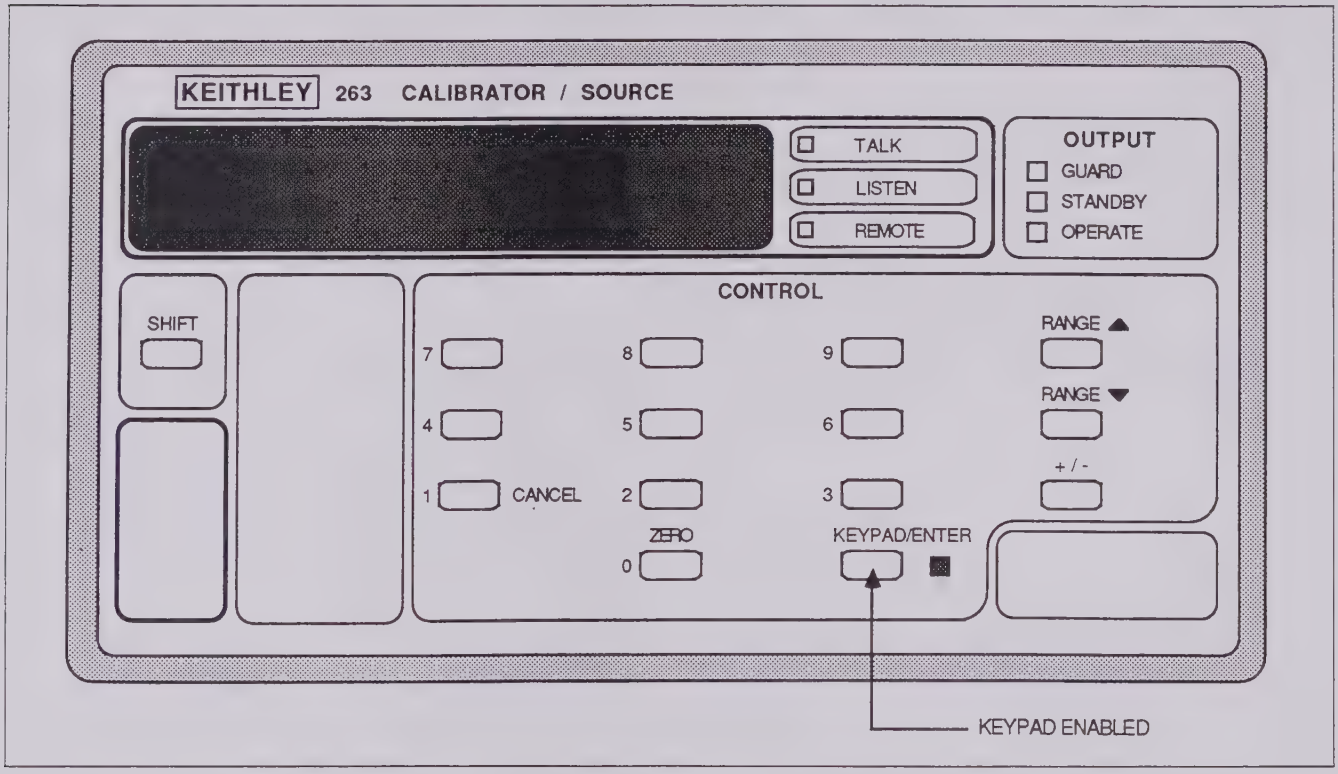


Figure 2-4. Data Entry Controls - Keypad Method

Step 5: Go To Standby

To remove the programmed source from the electrometer, again press the OPERATE button. The instrument will go to standby as indicated by the STANDBY indicator light.

Operating Notes:

1. AMPS V/R or COUL V/R may be selected in step 1 by first pressing SHIFT and then the AMPS or COUL button. The yellow V/R will turn on to indicate the selection of the passive V/R source.
2. If an external source is connected to the EXT INPUT and COMMON terminals, that source will be available at the OUTPUT by pressing SHIFT and then VOLTS. The yellow EXT indicator turns on and the message "USEr V" is displayed.

SECTION 3
Operation

3.1 INTRODUCTION

This section contains detailed information concerning the operation of the Model 263 from the front panel. The section is arranged as follows:

3.2 **Power Up Procedure:** Describes how to connect the instrument to line power and turn it on. Other topics covered include the power up self-tests, power up default conditions and the required warm up period.

3.3 **Output Characteristics:** Provides the user with some of the basic output characteristics of the various sources. Includes discussion on current limiting, loading and voltage burden. Understanding these aspects of operation is helpful in obtaining optimum performance from the instrument.

3.4 **Function and Range Selection:** Details how to select each sourcing function and how to change ranges.

3.5 **Data Entry:** Describes the two methods that can be used to program the output reading on the display of the Model 263.

3.6 **Operate and Zero:** Provides details for using these two front panel controls.

3.7 **Guard:** Describes how to use the Model 263 in the guarded output configuration.

3.8 **Preamp Out:** Explains some of the uses for the preamplifier output, which are accessible from the rear panel.

3.9 **Front Panel Programs:** Details information for using the three front panel programs.

3.10 **Sourcing Techniques:** Outlines how to combine all the operating controls to properly source each source parameter.

3.11 **Sourcing Considerations:** Provides additional information on temperature compensation, burden voltage and guarding.

3.2 POWER UP PROCEDURE

The information in the following paragraphs describe how to connect the Model 263 to the available line power and turn on the instrument.

3.2.1 Line Voltage

The Model 263 may be operated from either 105-125V or 210-250V, 50 or 60Hz sources. A special transformer may be installed (at factory) for 90-110V and 180-220V ranges. The instrument was shipped from the factory set for an operating voltage that corresponds to the normally available line voltage in your area. To check the line voltage setting, look at the position of the slide switch located on the rear panel (see Figure 3-1). If the switch is in the wrong position, the line fuse will probably have to be replaced with one that has a different rating. Refer to paragraph 8.2 in the maintenance section for the line voltage selection procedure.

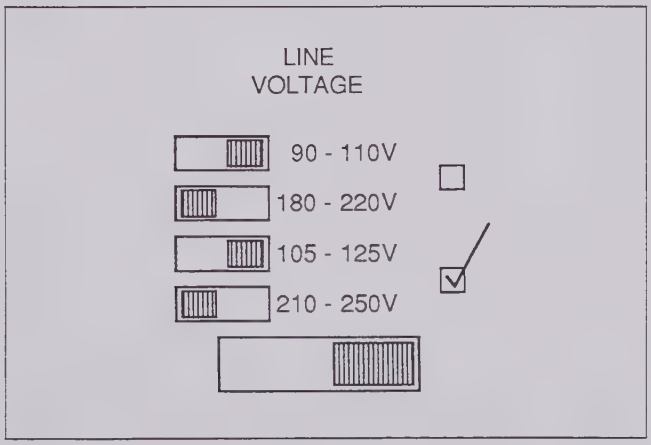


Figure 3-1. Line Voltage Switch

3.2.2 Line Power Connections

Using the supplied power cord, connect the instrument to an appropriate 50 or 60Hz AC power source. The female end of the cord connects to the AC receptacle on the rear panel of the instrument. The other end of the power cord should be connected to a grounded AC outlet.

WARNING

The Model 263 must be connected to a grounded outlet in order to maintain continued protection against possible shock hazards. Failure to use a grounded outlet may result in personal injury or death due to electric shock.

3.2.3 Power Switch

To turn on the power, simply push in the front panel POWER switch. Power is on the when the switch is at the inner position. To turn power off, press POWER a second time.

3.2.4 Power Up Self Test

During the power up cycle, the instrument will perform a number of internal tests. Tests are performed on memory (RAM, ROM, and NVRAM). If the tests are successful, the messages "r.r." and "r.o." will be displayed briefly. If RAM or ROM fails, the instrument will lock up. If NVRAM fails, the exponent decimal points (i.e. "m.V.") will blink on and off. See paragraph 8.7 for a complete description of the power up self-test and recommendations to resolve problems.

3.2.5 Power Up Configuration

Upon power up, the Model 263 will assume specific operating states. Table 3-1 summarizes the factory default conditions for the unit.

3.2.6 Warm Up Period

The Model 263 can be used immediately when it is first turned on. Note, however, that the unit must be allowed to warm up for at least one hour to achieve rated accuracy.

Table 3-1. Power Up Default Conditions

Feature	Condition
Output	Standby
Function	Volts
Range	200mV
Displayed Reading	000.000mV
Polarity	Positive (+)
Guard	Disabled
Cursor	Off, positioned on MSD
Keypad	Disabled
IEEE Address*	8
Exponent*	Alpha characters
Temperature Compensation	On

*These conditions can be changed by front panel programs to become the new power up default conditions.

3.3 OUTPUT CHARACTERISTICS

To obtain optimum performance from the instrument, it is important to be aware of its basic output characteristics. Sourcing aspects that affect performance include voltage source, current limit, loading, and burden voltage. The following paragraphs will explain these characteristics.

3.3.1 Voltage Source

The information in this paragraph provides a basic understanding of the output characteristics of the voltage source.

Voltage Source (VOLTS)

A simplified circuit of the voltage source is shown in Figure 3-2. V_s is the voltage setting of the Model 263 and R_s ($<1\Omega$) is the output resistance of the source. To deliver the programmed voltage to the load at the accuracy stated in the specifications, the load must be $>100k\Omega$.

When connecting a low resistance load to the output, its effect on the circuit must be considered. The load resistance and the internal resistance of the source (R_s) form a voltage divider. Thus, if the load resistor is 10k,

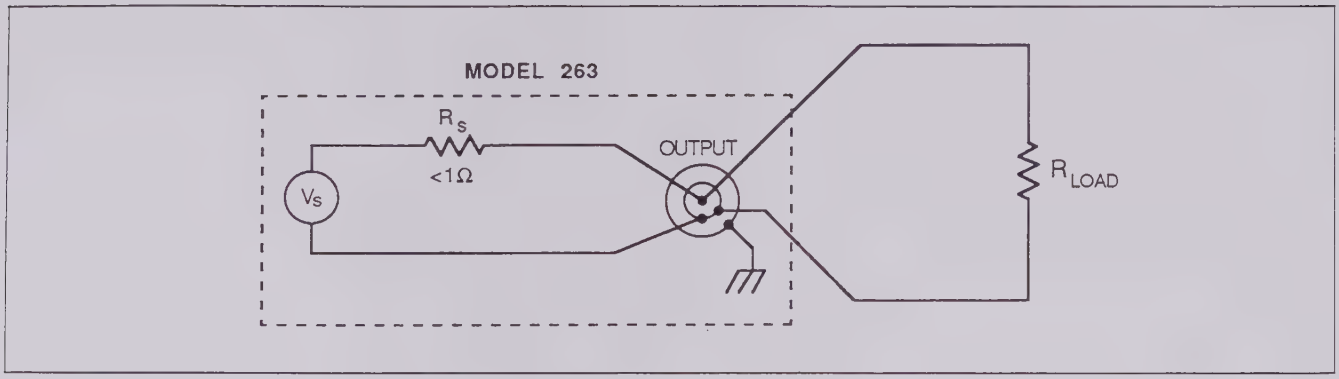


Figure 3-2. Voltage Source

approximately 99.99% of V_S will be delivered to the load. This 0.01% additional error will degrade basic volts accuracy from 0.0175% to 0.0275%. The actual voltage delivered to the load can be calculated as follows:

$$V_{OUT} = \frac{V_S \times R_L}{(R_L + R_S)}$$

where
V_{OUT} = Voltage delivered to the load
V_S = Voltage setting of the 263
R_L = Resistance of the load
R_S = Output resistance of the source (1Ω)

If the load is <100kΩ, additional error is calculated as follows:

$$\text{Additional Error (\%)} = \frac{1\Omega}{\text{Load Resistor} + 1\Omega} \times 100$$

External Source (EXT INPUT)

EXT INPUT is provided so that the Model 263 can switch select an external source of up to 200V and 100mA. This feature eliminates the need to physically disconnect the Model 263 from the device under test (DUT) in order to connect an external source to the DUT. This is particularly handy when running automated test programs over the IEEE-488 bus.

Since internal VOLTS only outputs up to ±19.9995 and ±19.9995mA, an external source can be used to calibrate instruments that have higher voltage and current requirements. A simplified circuit showing an external source connected to EXT INPUT is shown in Figure 3-3. Maximum inputs for EXT INPUT are 200V peak and 100mA peak. Staying within these limits will protect the Model 263 from damage.

As with the internal voltage supply, connecting a high impedance device (such as an electrometer) to the output will not result in any loading problems. For low resistance loads and high currents, EXT INPUT circuit resistance (1Ω) should be taken into account. When sourcing voltage through the Model 263, use the following equation to calculate voltage drop through the Model 263:

$$V = \frac{1\Omega}{1\Omega + R_{EXT} + R_{LOAD}} \times V_{EXT}$$

where

V = Voltage drop through the 263.
R_{EXT} = Output resistance of the external voltage source.
R_{LOAD} = Load resistance.
V_{EXT} = Voltage setting of the external source.

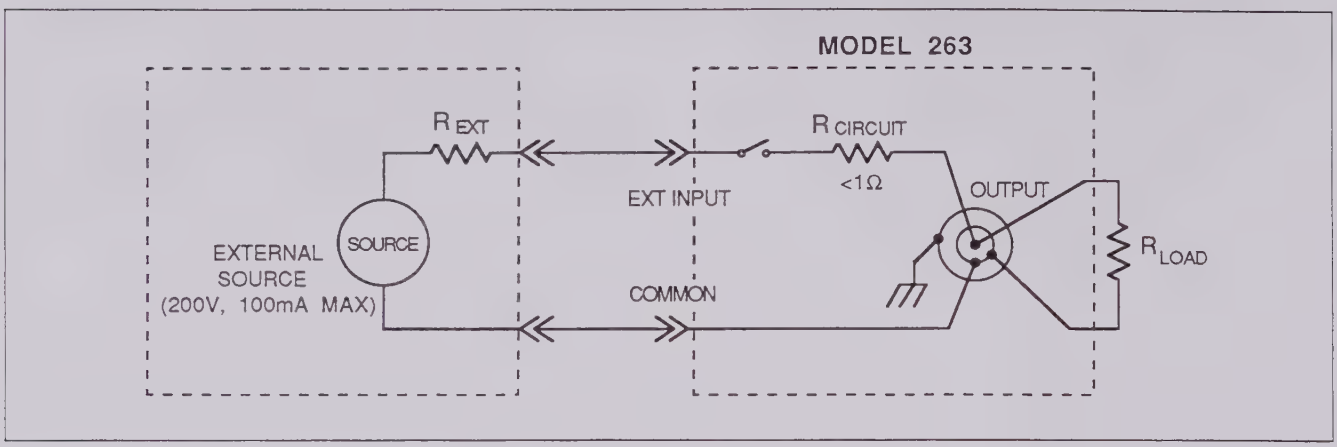


Figure 3-3. External Source

When sourcing current to EXT INPUT, maximum burden voltage of the Model 263 can be calculated as follows:

Maximum Burden V = 1Ω × I

where

I = Current setting of the external source.

3.3.2 Resistance Source

Resistance sourcing is a simple matter of selecting the appropriate resistor. When the Model 263 is calibrated, the resistors are accurately measured and the instrument is adjusted to display those values. Thus, when the instrument is configured to source a resistance, the display will provide the measured reading of that resistor.

On the 1GΩ, 10GΩ and 100GΩ ranges, the resistor reading on the display will change as the instrument warms up, and as ambient temperature changes occur. These resistors have a high negative temperature coefficient (TC). As the temperature of the resistor rises, its resistance decreases. The display is able to track the output resistance because a TC profile for each of these three resistors is established when the instrument was calibrated. In effect, the instrument "knows" what the output resistance is at all operating temperatures. This temperature compensation feature can be disabled by front panel Program tc (see paragraph 3.9.3). With temperature compensation disabled, the instrument will display the resistor reading that was measured (during calibration) when the internal temperature approximated the normal operating temperature. See paragraph 3.11.1 for more information on temperature compensation.

3.3.3 Current and Charge Source

The Model 263 provides two methods to source current for the current and charge functions. When the AMPS or COUL button is pressed, the active current source is selected. When SHIFT AMPS or SHIFT COUL is pressed, the passive (V/R) source is selected.

Active Current Source (AMPS)

Figure 3-4 shows a simplified schematic of the active current source (AMPS). With this method, the output current remains at the programmed level regardless of the load resistance, as long as the compliance voltage of ±12V is not exceeded. Compliance voltage is the maximum voltage that can appear across the unknown with the programmed current still being sourced.

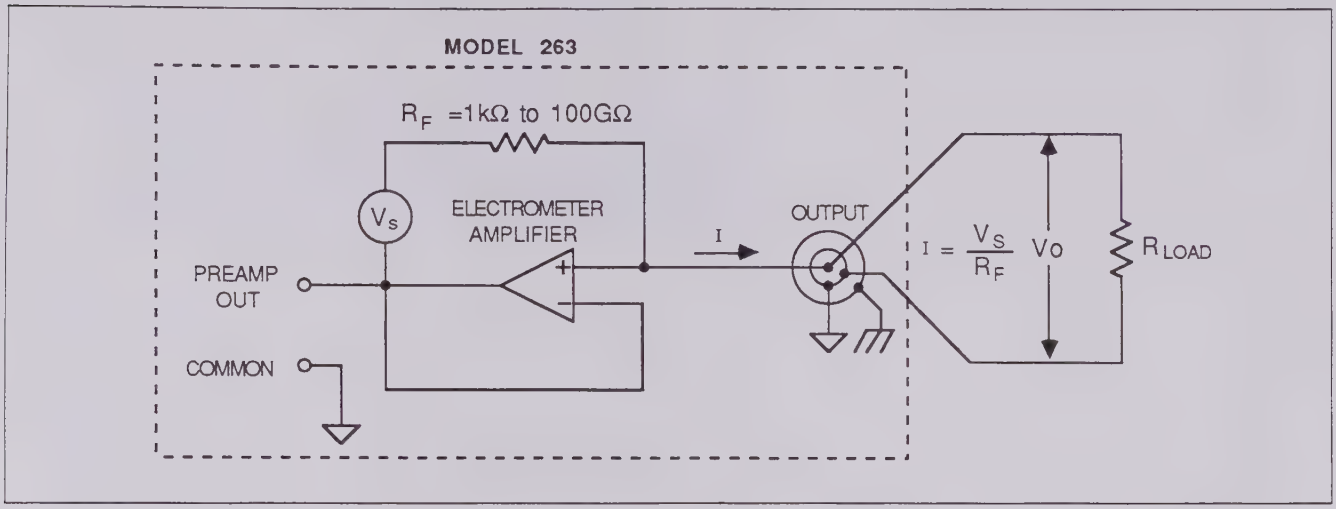


Figure 3-4. Active Current Source (Unguarded)

Example—Model 263 configured to output 1mA to a 5kΩ load. The value of V_s is determined by the programmed current level and the feedback resistor (R_F). On the 1mA range the 10kΩ feedback resistor is used. Thus, V_s is 10V (10kΩ × 1mA). The voltage drop (V_o) across the load (R_{LOAD}) is 5V (1mA × 5kΩ).

If the voltage compliance limit is surpassed, the OPERATE light will flash on an off indicating that the instrument cannot source the programmed current level to the load.

Example—Model 263 configured to output 1mA to a 20kΩ load. Sourcing 1mA to a 20kΩ resistor would result in a V_o of 20V (1mA × 20kΩ). However, V_o will limit (OPERATE light flashing) at approximately 12V which is the compliance limit, and the resulting output current will be less than 1mA.

To prevent the voltage limit condition (flashing OPERATE light) make sure that the product of the programmed output current times the load resistance is less than 12V ($I \times R < 12V$).

Notes:

1. Voltage limit will never occur when sourcing to a feedback ammeter since the burden voltage of this device is so low. The burden voltage, typically 1mV or less, is the voltage drop seen across the input of the electrometer or picoammeter.
2. The compliance voltage is a minimum of ±12V, but will probably approach ±15V before the OPERATE light flashes.

Passive Current Source (AMPS V/R)

Figure 3-5 shows a simplified schematic of the passive current source. The values of R and V_s are dependent on the selected range and output setting. The values of R and V_s are selected such that the programmed current will flow in the circuit when the output is connected to a virtual ground. Thus any device, whether it be a resistor or an electrometer, will cause a loading error to some degree.

Example—With the Model 263 configured to output 1mA on the 2mA range, the value of R will be 1kΩ (see Table 3-4) and V_s will be at 1V (1mA × 1kΩ). If the output of the Model 263 is shorted, 1mA will flow in the circuit. If the output is connected to a 1kΩ load, only 0.5mA will flow in the circuit.

In this simple series circuit, it is obvious that the only way to source current at the programmed setting is to connect the output to a virtual short. This is why the output of the passive current source should only be connected to a device (picoammeter) that has a low burden voltage. Burden voltage is the voltage drop seen across the device. The current source accuracy specifications, excluding offset, include the error introduced by devices that have a 100μV burden voltage. The additional error caused by devices that have more than 100μV of burden voltage can be calculated (see paragraph 3.11.2).

Calibrating an electrometer that has a burden voltage specification of >100μV is not a problem as long as the input offset voltage of the input amplifier can be adjusted. Nulling out the offset voltage of the picoammeter input amplifier can reduce the burden voltage to almost zero.

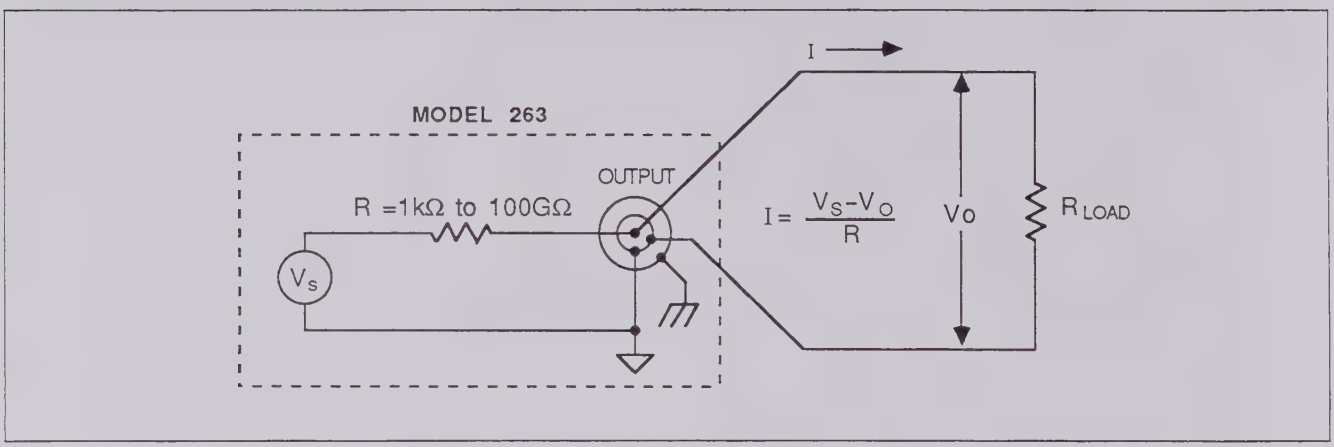


Figure 3-5. Passive (V/R) Current Source

Charge Source

The Model 263 outputs charge by sourcing a specific current level for one second. This technique is based on the following fundamental charge equation:

$$Q = I \times t$$

where
Q = Charge in coulombs
I = Current in amperes
t = Time in seconds

If the Model 263 is programmed to output a charge of 10μC, it will actually output 10μA for one second. Thus the fundamental difference between the current function and the charge function is the time duration of the output current. COUL uses the active current source, while COUL V/R uses the passive current source.

3.4 FUNCTION and RANGE SELECTION

The following paragraphs provide the information needed to select function and range.

3.4.1 Function Selection

Ohms—To select the ohms function, simply press the OHMS button. The OHMS light will turn on.

Volts—To select the volts function, simply press the VOLTS button. The red VOLTS indicator will turn on.

EXT INPUT—To select EXT INPUT first press SHIFT and then press VOLTS. The yellow EXT indicator will turn on.

AMPS—To select the active current function, press AMPS. The red AMPS indicator will turn on.

AMPS V/R—To select the passive (V/R) current function, first press SHIFT and then press AMPS. The red AMPS light and the yellow V/R indicator will turn on.

COULOMBS—To select the active charge function, press COUL. The red COUL indicator will turn on.

COULOMBS V/R—To select the passive (V/R) charge function, first press SHIFT and then press COUL. The red COUL indicator and the yellow V/R light will turn on.

Note: Any time a function button is pressed, the output will go to the standby condition.

3.4.2 Range Selection

The RANGE buttons are used to change ranges. Each momentary press of RANGE ▲ upranges the display to the next highest range, while RANGE ▼ downranges to the next lowest range. These buttons have auto-repeat capability. That is, holding in a RANGE button will cause the instrument to continually uprange (▲) or downrange (▼) until the largest or smallest range is reached.

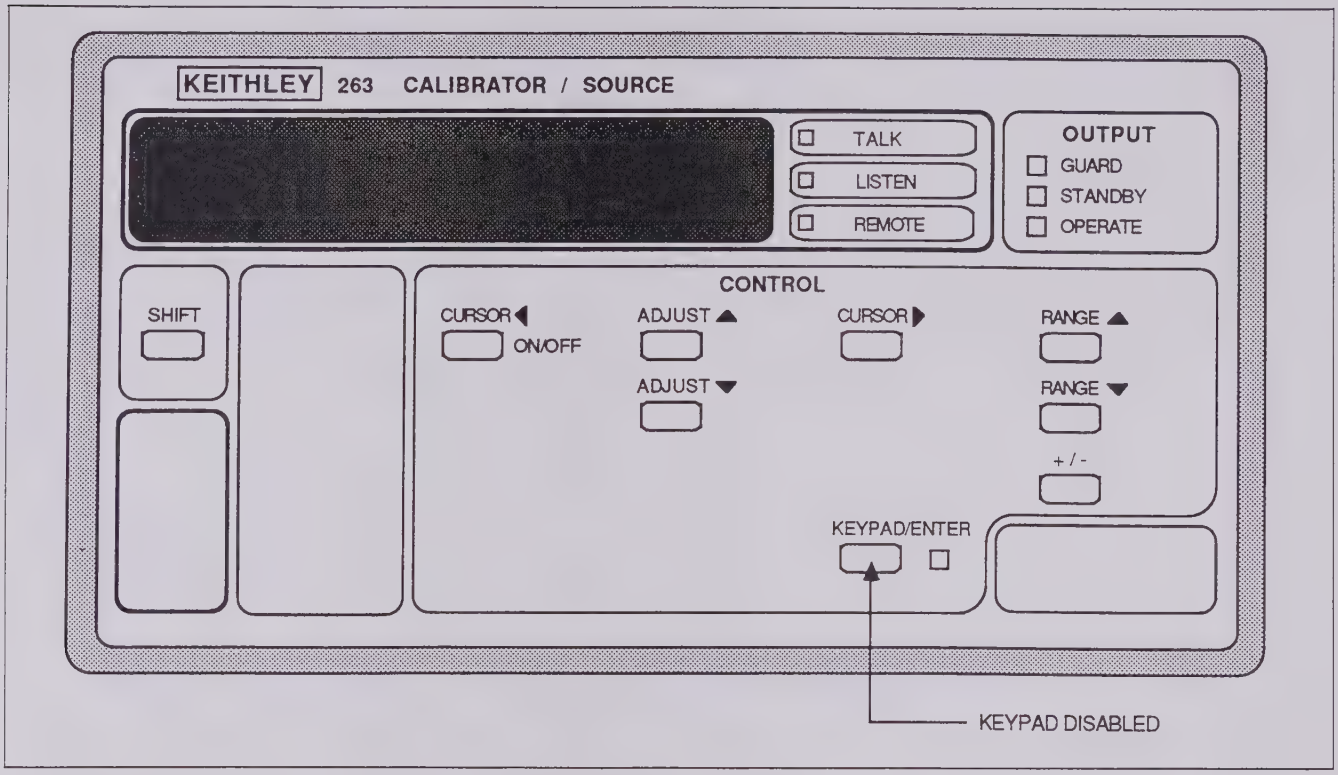


Figure 3-6. Data Entry Controls - Adjust Method

Available ranges depend on the selected function and are listed in the specifications. Note that the ohms ranges in the specifications list the nominal resistance values. The actual values of the resistors are displayed by the instrument.

As a general rule, always select a range that meets the best accuracy and resolution requirements.

Output Response—When a range button is pressed while on any function, except OHMS, the output will immediately go to zero for a half second and then ramp to the new output level in $< \frac{1}{2}$ second. In OHMS, output changes are immediate.

3.5 DATA ENTRY

The output value of all functions on a given range, except ohms, can be modified. There are two methods to change the display to the desired output reading; the Adjust method and the Keypad method. The method to use depends on your preference, but when making minor changes to the displayed reading, the Adjust method is probably faster. Keypad entry is the best choice when an entirely new reading is going to be entered.

3.5.1 Adjust Method

Refer to Figure 3-6 and perform the following procedure to change the display reading using the adjust method:

1. Position the cursor on the digit to be changed using the CURSOR buttons.

   Cursor position is identified by a briefly flashing digit segment whenever a CURSOR button is momentarily pressed. Each momentary press of CURSOR ◄ moves the cursor one digit to the left, and each press of CURSOR ► moves the display one digit to the right. The CURSOR buttons have auto-repeat capability. That is, holding in a CURSOR button will cause the cursor to scroll from left-to-right (►) or from right-to-left (◄).

   Note: The cursor can be turned on by pressing SHIFT ON/OFF. A segment of the selected digit (indicating cursor position) will flash continuously. To turn the cursor off, again press SHIFT ON/OFF. The cursor will also disable anytime a function button is pressed.

2. Adjust the display reading using the ADJUST buttons.

   Each momentary press of the ADJUST ▲ button will increment the reading by one unit (value is determined by range and cursor position). For example, with the instrument on the 20mA range and the cursor positioned on the thousanths digit (second digit from the right), each press of ADJUST ▲ will increment the reading by 1μA. Conversely, each momentary press of ADJUST ▼ decrements the reading by one unit. The exception to this rule is the least significat digit that changes by five units when an ADJUST button is pressed. The ADJUST buttons also have auto-repeat capability. That is, holding in an ADJUST button will cause the reading to increment (▲) or decrement (▼) automatically.

Notes:

1. Polarity of the reading can be changed by pressing the ± button.
2. Polarity of the reading will also change when the display is adjusted past zero.
3. The display reading cannot be adjusted past the limits of the range. However, range changes can be made at any time.
4. If the instrument is in OPERATE, the output will change as the display reading changes.

3.5.2 Keypad Method

Refer to Figure 3-7 and perform the following procedure to enter a reading on the display:

1. Enable the keypad by pressing KEYPAD/ENTER.

   The KEYPAD light will turn on and a segment of the most significant digit will flash to indicate the position of the cursor.
2. Key in the reading using the numeric data entry buttons.

   With the cursor at the most signficant digit, key in the desired number by pressing the appropriate number button (0 through 9). The rest of the display digits will zero and the cursor will move to the next less significant digit. Key in as many numbers as necessary. The least significant digit can only be a 0 or a 5. Keying in 0 to 4 will set that digit to 0, and keying in 5 to 9 will set it to 5.
3. Enter the keyed in reading by again pressing KEYPAD/ENTER.

   The new reading will be entered and keypad will disable. Prior to this step, the display reading was changed, but the output was not affected.

Notes:

1. Press the ± button to change the polarity of the display reading.
2. Range changes can be made with the keypad enabled.
3. A keyed in reading can be cancelled by pressing (SHIFT) CANCEL. The keypad will disable and the display will return to the reading that was on the display before keypad was enabled.
4. Pressing any function button is the same as pressing (SHIFT) CANCEL (see Note 3), however, the instrument will go to (or stay at) the selected function.

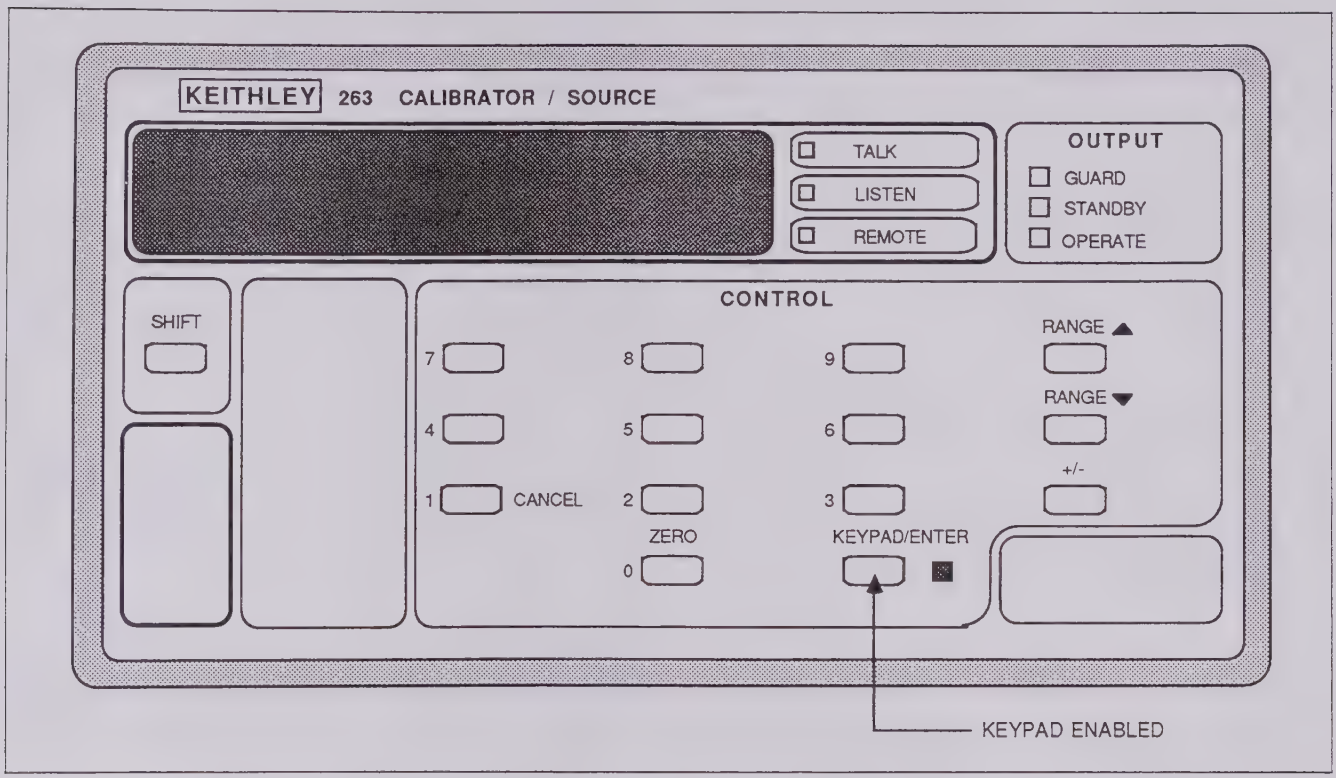


Figure 3-7. Data Entry Controls- Keypad Method

3.6 OPERATE and ZERO

The following paragraphs contain information on the OPERATE and ZERO features.

3.6.1 Operate

The OPERATE button toggles the output between standby and operate. In standby, yellow STANDBY light on, for all functions except COUL and COUL V/R, the 100GΩ resistor is placed on the output. In COUL and COUL V/R, zero coulombs, on the range selected, is placed on the output.

In the coulombs function, the instrument will only stay in operate for approximately one second each time the OPERATE button is pressed.

3.6.2 Zero

The ZERO button toggles the display between the existing reading and zero. This provides an easy method to source zero in order to cancel offsets and test lead resistance. The output must be set to OPERATE in order to source zero.

On all functions except OHMS, particularly on the most sensitive ranges, the Model 263 has a very slight offset that is added to the output. The maximum offset output on each function/range is included in the accuracy specification. This offset is present whether the instrument is sourcing zero or full range.

When zero is sourced to an electrometer or picoammeter, the offset of the Model 263 will be measured. The electrometer/picoammeter can then suppress the offset so that it also reads zero. The readings on the electrometer or picoammeter will then accurately track the displayed output of the Model 263.

To achieve rated accuracy when sourcing 1kΩ or 10kΩ to an electrometer, zero must be used to cancel ZERO OFFSET and test lead resistance. When zero ohms is sourced to an electrometer, the resistance measurement will include these resistances. The electrometer can then suppress the reading so that it also reads zero.

The procedures to zero out offset and test lead resistance are included in the sourcing techniques in paragraph 3.10.

3.7 GUARD

In general, the purpose of guarding is to eliminate leakage resistance and capacitance that exist between output high and output low. In the unguarded configuration (see Figure 3-8), leakage occurs between the center conductor (HI) and the inner shield (LO) of the output triax cable. This leakage (through R_l and C_l) may be enough to adversely affect the output level and response time of the source.

In the guarded configuration (see Figure 3-9), output low is connected to common, allowing a guard potential (equal to the potential at ouput high) to be connected to the inner shield of the cable. With the voltage potential on output high and the inner shield the same, no leakage current can flow. The leakage from the guarded inner shield to low (through R_G and C_G) is of no consequence since the current is supplied from the guard source (V_G) and not from output high. More information on the principles of guarding is contained in paragraph 3.11.3.

The Model 263 supplies the guard drive for AMPS and COUL. However, the user must supply the guard drive for AMPS V/R, COUL V/R, OHMS and VOLTS. When GUARD is enabled with any of these functions selected, the inner shield of the triax connector is floating unless a guard drive is supplied by the user.

Guard Enable—To place the output of the Model 263 in a guarded configuration press SHIFT GUARD. The yellow GUARD light will turn on. Pressing SHIFT GUARD a second time will disable guard and return the output to the unguarded configuration.

Whenever GUARD is enabled, source output low is physically connected to the COMMON terminal. Therefore, always use a separate cable to connect COMMON of the Model 263 to common of the device under test (DUT).

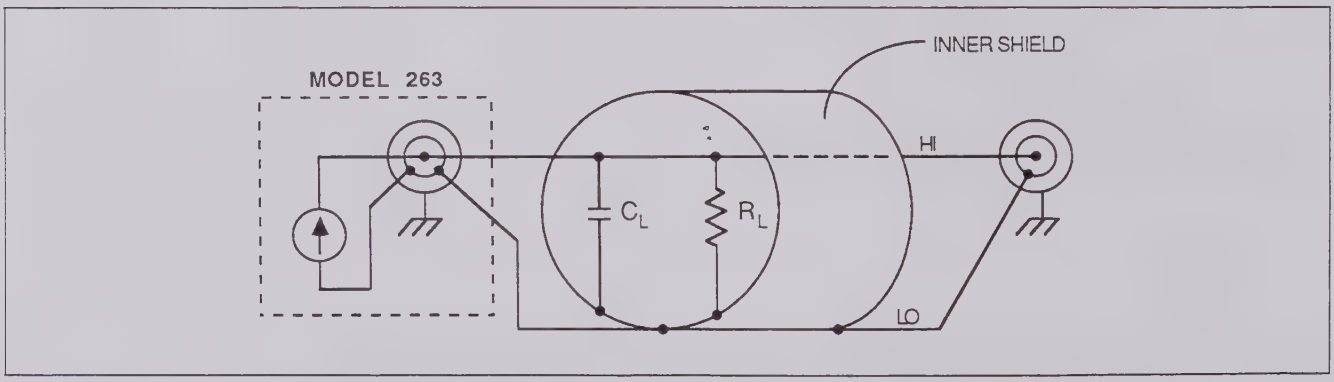


Figure 3-8. Unguarded Circuit

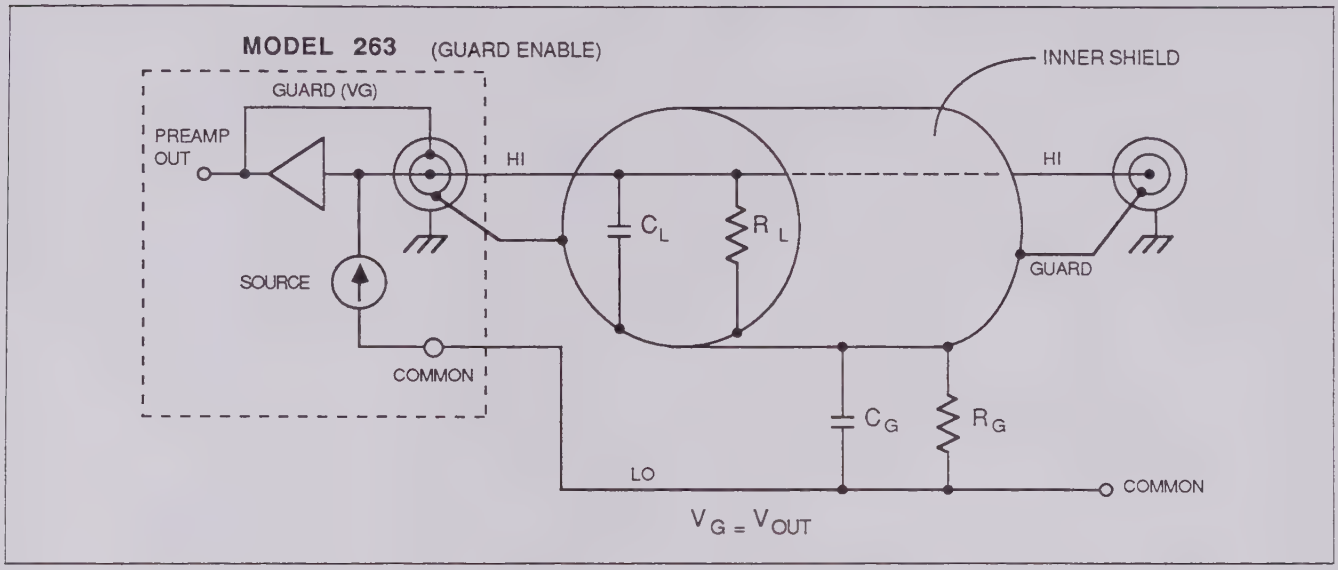


Figure 3-9. Guarded Circuit

3.7.1 Guarded Ohms

WARNING

Hazardous voltage may be present on the inner shield of the OUTPUT connector when sourcing guarded ohms. A safety shield (outer shield of the supplied triax cable) connected to earth ground should be used.

Guarding is recommended for resistances ≥100MΩ. The unguarded and guarded output configuration for ohms is shown in Figure 3-10. With guard enabled, output low is physically disconnected from the inner shield of the OUTPUT connector on the rear panel of the Model 263. This allows guard drive to be connected to the inner shield. In OHMS, guard drive (the inner shield of the triax connector and cable) must be provided by the external DUT.

Most electrometers have an output connector that provides a guard drive. Some electrometers (such as the Keithley Model 617) have the capability to reconfigure its input (through means of a switch) and internally connect the guard drive to the inner shield. With this capability, connecting the Model 263 to the electrometer is a simple matter as shown in Figure 3-11. For electrometers whose input cannot be reconfigured, an input adapter will be required. The objective of the adapter is to connect the guard source of the electrometer to the inner shield (guard) of the Model 263. Two such input adapters are available from Keithley. The Model 6167 is used with Keithley Model 614 Electrometer, while the Model 6191 is used with the Keithley Model 619 Electrometer. Figure 3-12 shows how the Model 263 is connected to an electrometer (Model 619) using an input adapter (Model 6191). Note that in Figures 3-11 and 3-12 source low is routed to the electrometer using a separate banana plug cable. This cable eliminates the need to route source low through earth ground connections that may have higher resistance.

In some electrometers there is a resistor (typically 100Ω or 1kΩ) connected between common and low (see Figure 3-11). In guarded ohms this resistor is in series with the output resistor of the Model 263. In this situation, never use guard to source ≤100MΩ to the Model 617 and ≤10MΩ to the Model 614. In the unguarded configuration, source low is routed directly to meter low.

Table 3-2 summarizes the techniques to source guarded ohms to Keithley electrometers.

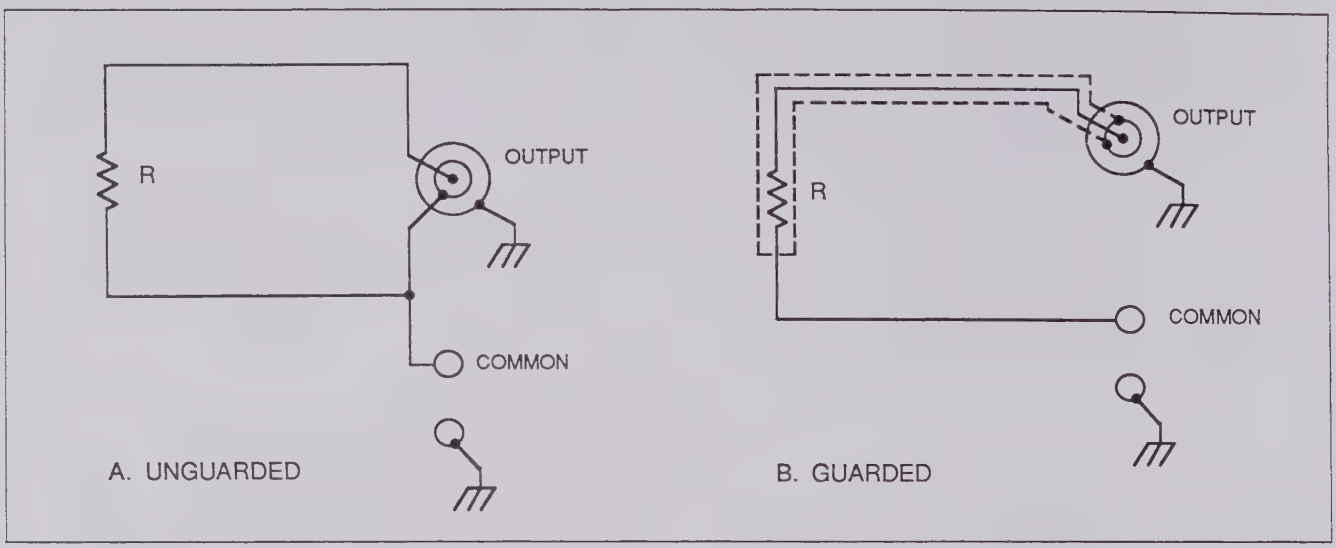


Figure 3-10. Ohms Output Configurations

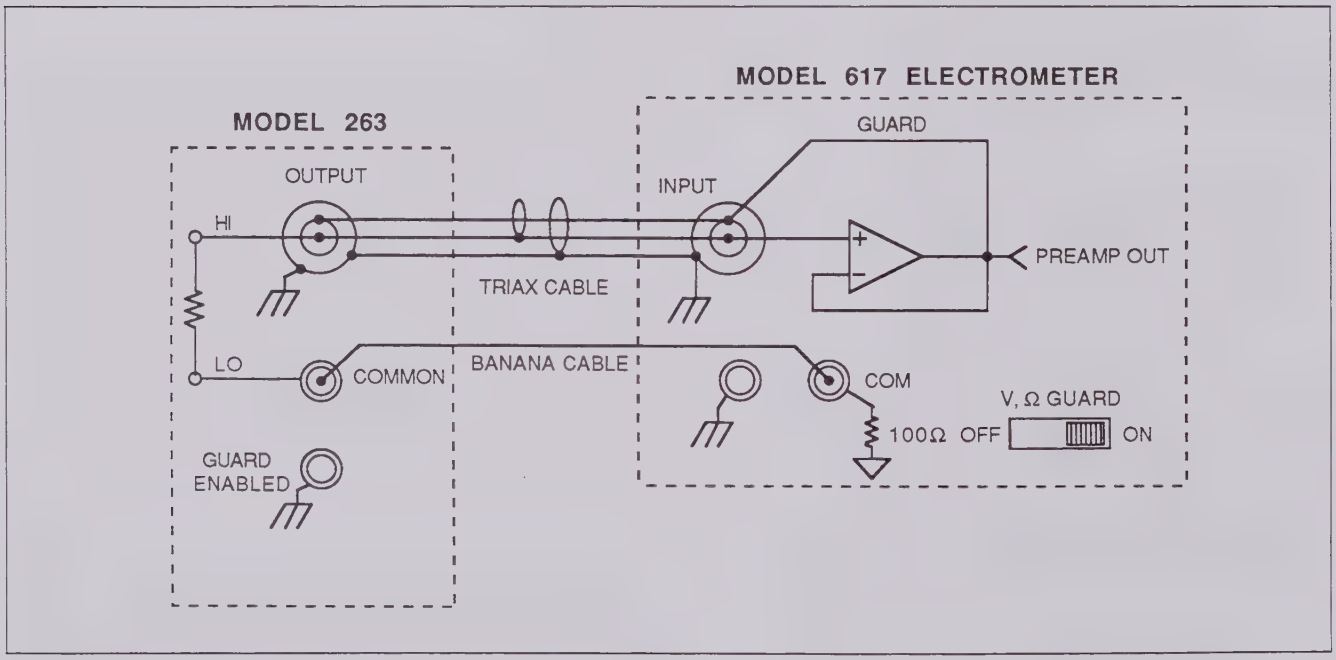


Figure 3-11. Sourcing Guarded Ohms to Electrometer that has a Selectable Guarded Input

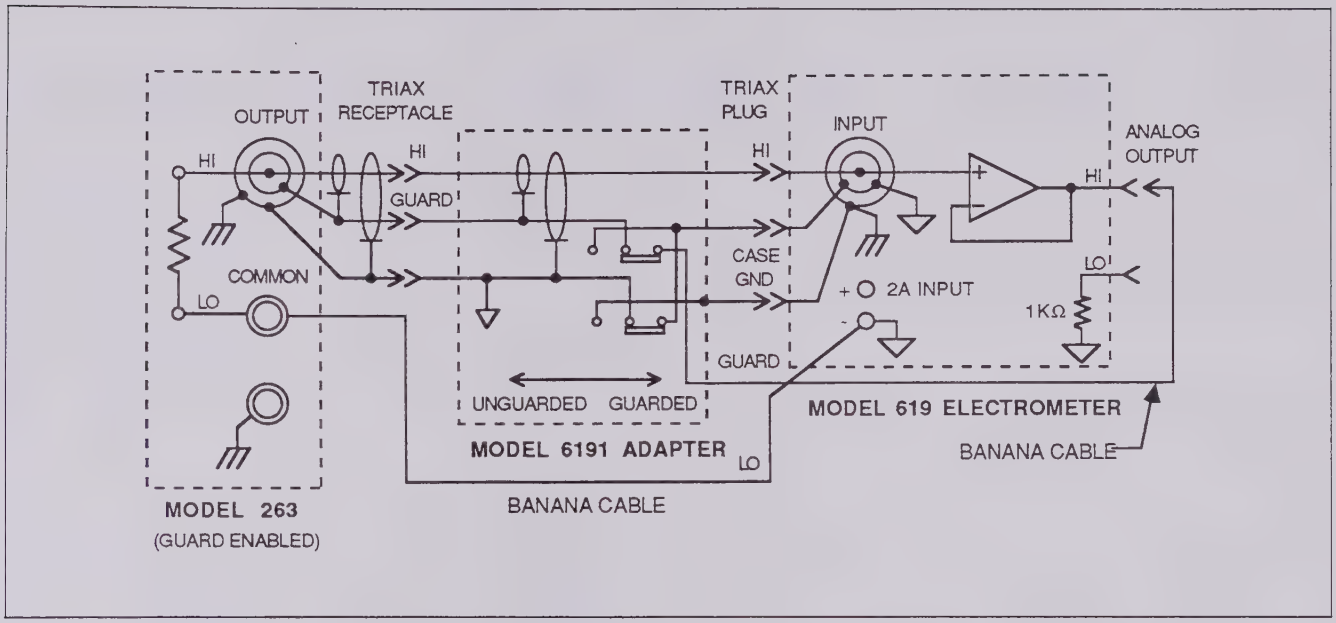


Figure 3-12. Sourcing Guarded Ohms to Electrometer Using an Input Adapter

Table 3-2. Sourcing Guarded Ohms to Keithley Electrometers

Model No.	Selectable Guarded Input Available?	Required Input Adapters* (Keithley Model No.)	Guarded Ohms Measurement Range	Connection Scheme
602	Yes	None	All	Figure A
610C	No	4804, CS-115	All	Figure B
614	No	6167	>100MΩ	Figure C
616	Yes	None	All	Figure D
617	Yes	None	>10MΩ	Figure E
619	No	6191	All	Figure F

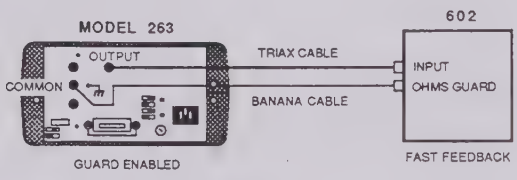


FIGURE A.

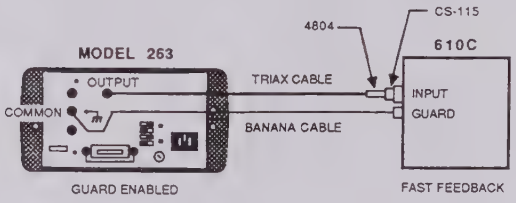


FIGURE B.

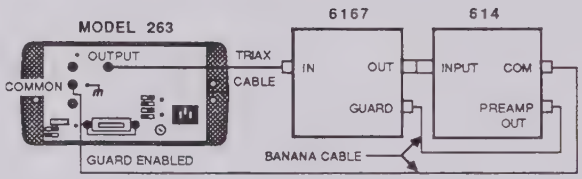


FIGURE C.

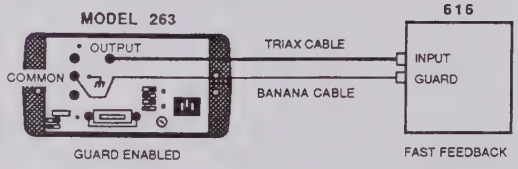


FIGURE D.

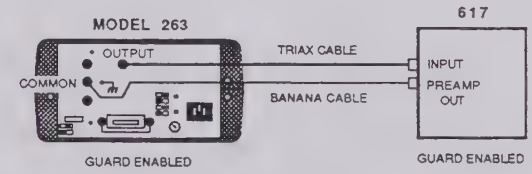


FIGURE E.

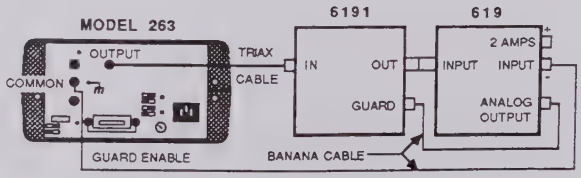


FIGURE F.

*THE MODELS 6167 AND 6191 ARE GUARDED INPUT ADAPTERS. THE MODEL 4804 IS A MALE BNC TO FEMALE TRIAX ADAPTER. THE MODEL CS-115 IS A MALE UHF TO FEMALE BNC ADAPTER

3.7.2 Guarded Amps and Coulombs

NOTE

The following discussion on guarded amps also applies to the Coulombs function.

The unguarded and guarded output configurations for amps is shown in Figure 3-13. With guard enabled, output low is disconnected from the inner shield of the OUTPUT connector, and the internal guard drive is connected to that inner shield. Output low can be routed to the outer shell of the output connector by installing the shorting link. However, installing the link connects output low to chassis ground, eliminating the floating capability of the instrument.

There is no need to use guard if the Model 263 is sourcing current to a feedback picoammeter as this circuit is already guarded. Figure 3-14 shows the Model 263 connected to a feedback picoammeter. Because the voltage drop (burden voltage) across the input of the picoammeter is very low (typically <1mV), the voltage on HI and LO are are virtually identical. With the same voltage potential, no leakage current can flow.

The Model 263 can be used in the guarded configuration if it is connected to a shunt picoammeter. The shunt or "NORMAL" configuration is only available on older electrometers, such as the Keithley Models 602 and 610C. The input of a shunt picoammeter is actually configured as a shunt electrometer voltmeter. The guarding technique is similar to the one used for sourcing ohms to an electrometer using an input adapter. Both the Keithley Models 6191 and 6167 Input Adapters can be used with the Model 602. Figure 3-15 shows how the Model 263 is connected to a shunt picoammeter (Model 602 set for "NORMAL" amps) using an input adapter (Model 6191). Notice that the guard cable from the input adapter is not connected to the electrometer since guard voltage is provided by the Model 263.

Guarding is recommended when sourcing current or charge to a high impedance load. A recommended guarding method is shown in Figure 3-16. With this method output high is guarded all the way to the load.

In AMPS and COUL, guard drive is also available at the PREAMP OUT terminal on the rear panel. Guard drive is available at that terminal in both the guarded and unguarded configurations. Figure 3-17 shows an application for the external guard. This configuration makes it possible to source current to a particular resistor (R1) without disconnecting other components (R2 and R3) in the resistor network. As configured, all of the output current will flow through R1. This is because virtually the same voltage potential exists on both sides of R2. In reality, a slight voltage difference exists because of the voltage offset of the preamplifier. In most situations, the resultant current through R2 is insignificant. The current that flows from PREAMP OUT through R3 is of no consequence.

In AMPS V/R and COUL V/R, guard drive is not available at PREAMP OUT. Since AMPS V/R and COUL V/R are usually used to calibrate electrometers, grounding is not needed. If sourcing AMPS V/R or COUL V/R to a load, a guard drive will have to be obtained from an external device.

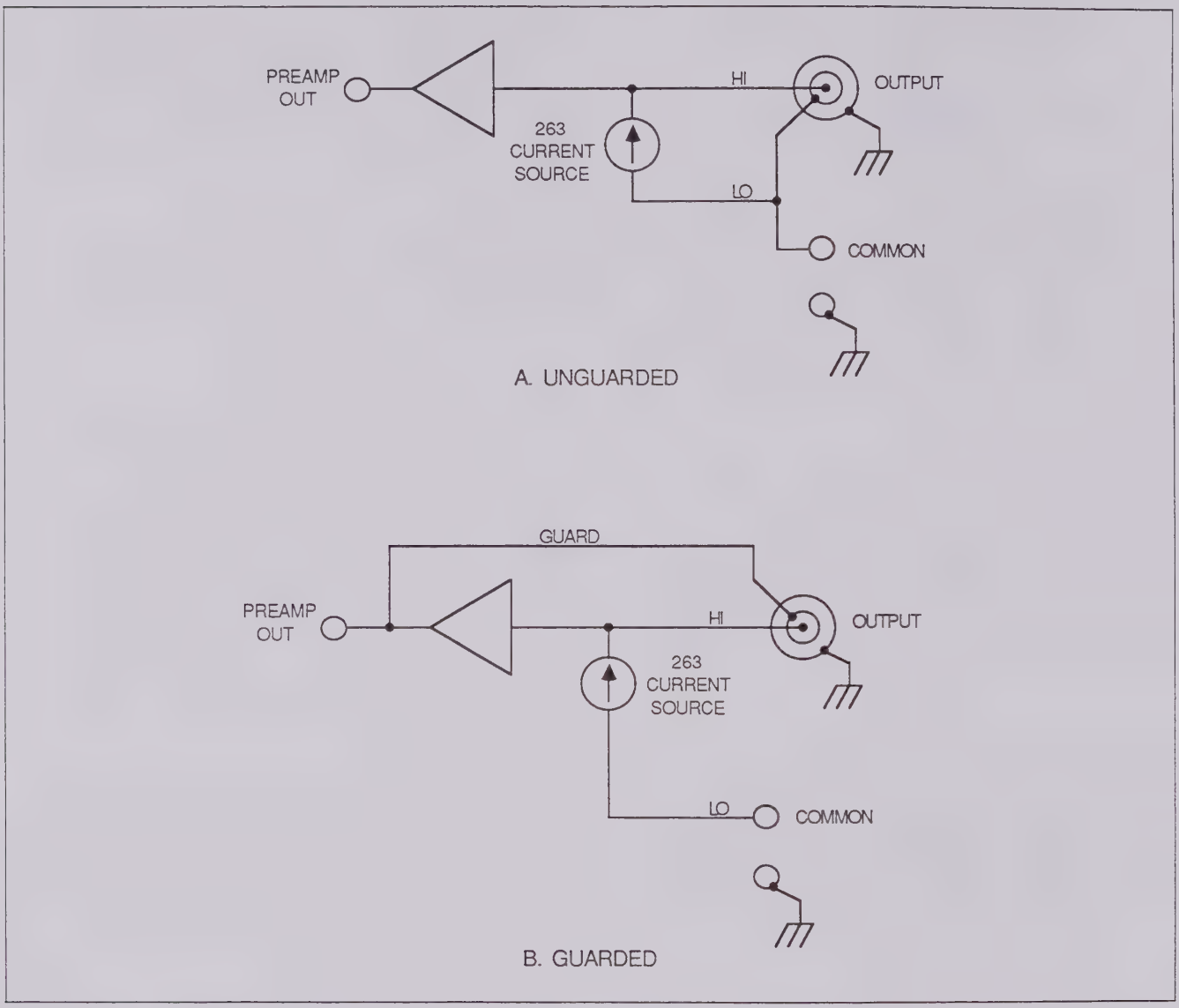


Figure 3-13. Amps/Coulombs Output Configurations

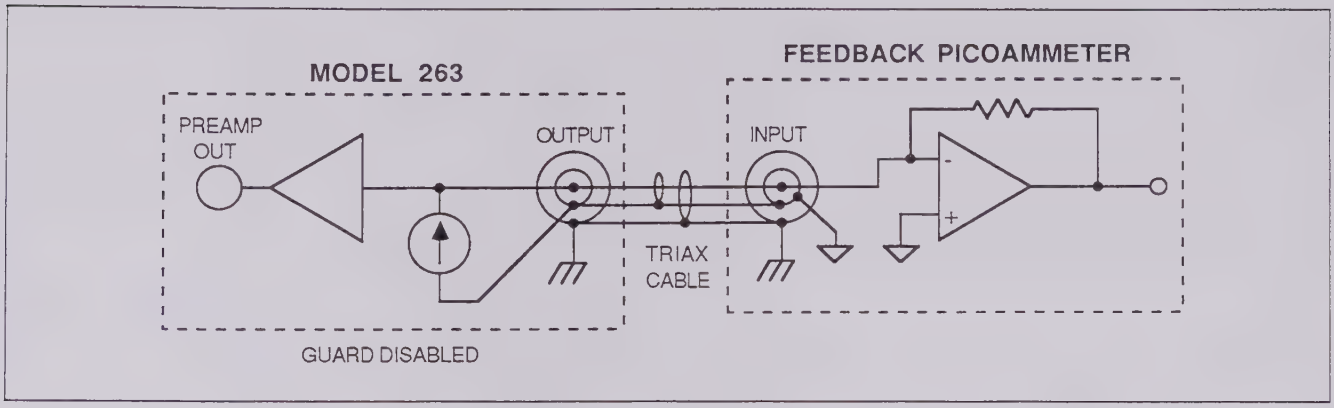


Figure 3-14. Sourcing Amps to a Feedback Picoammeter

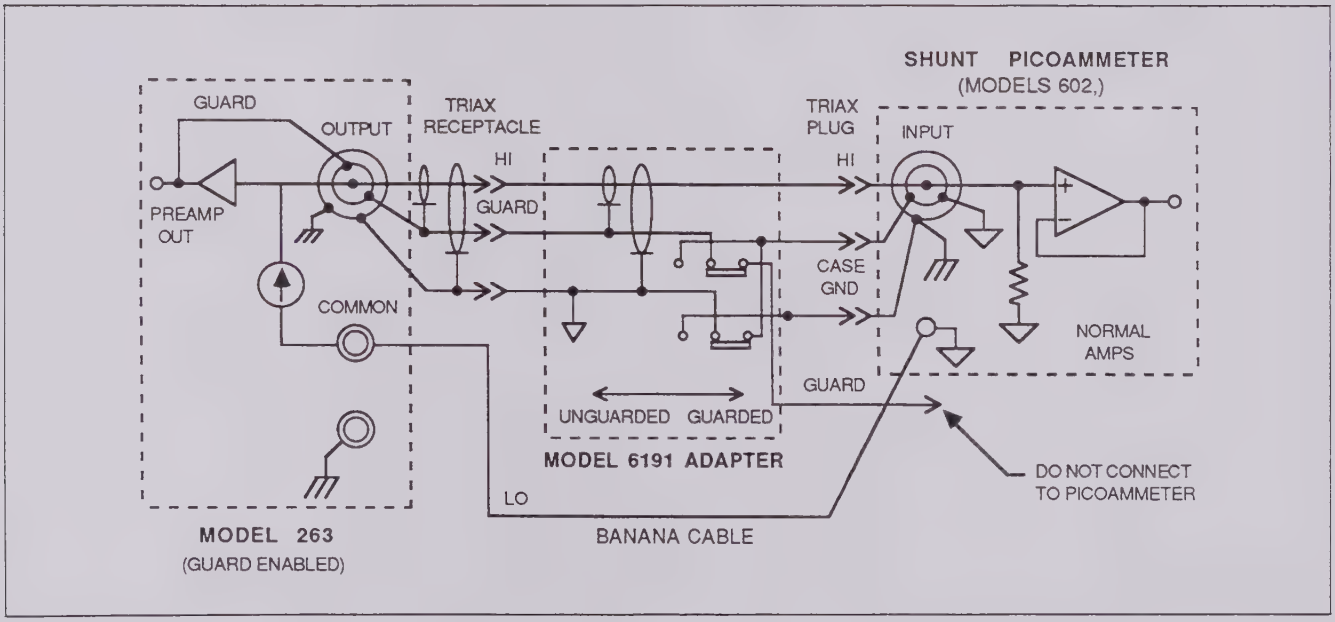


Figure 3-15. Sourcing Guarded Amps to a Shunt Picoammeter Using an Input Adapter

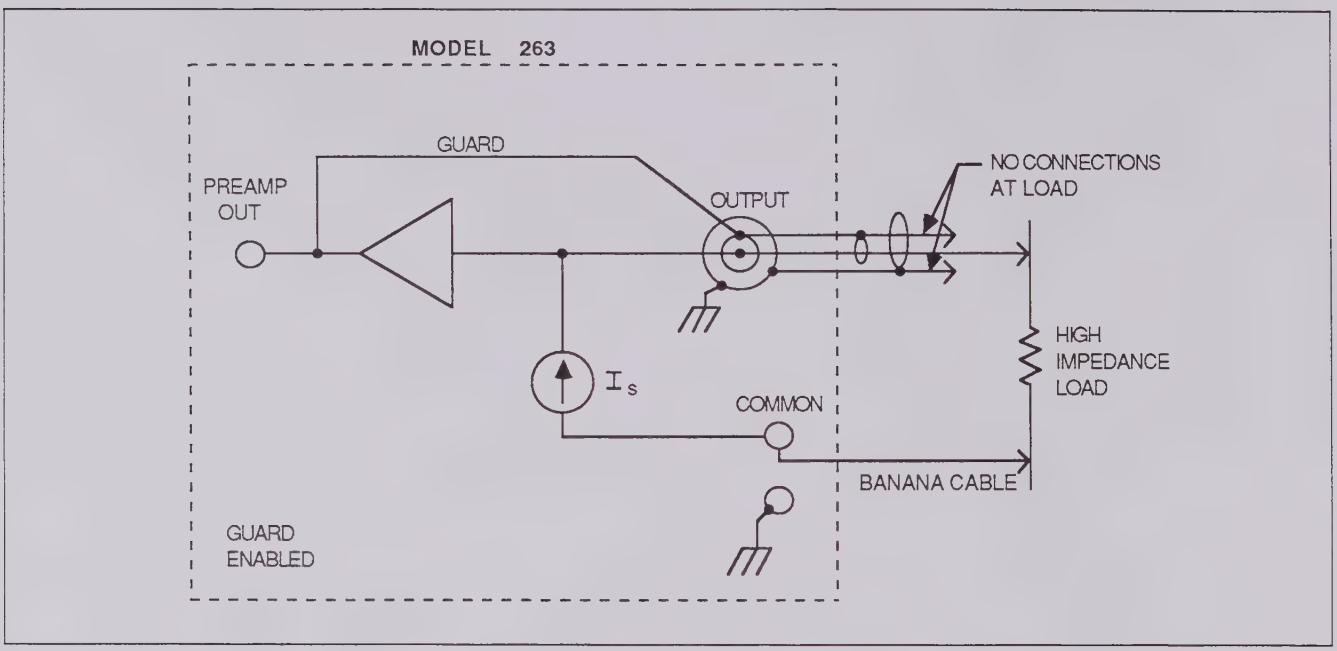


Figure 3-16. Guarding for High Impedance Load

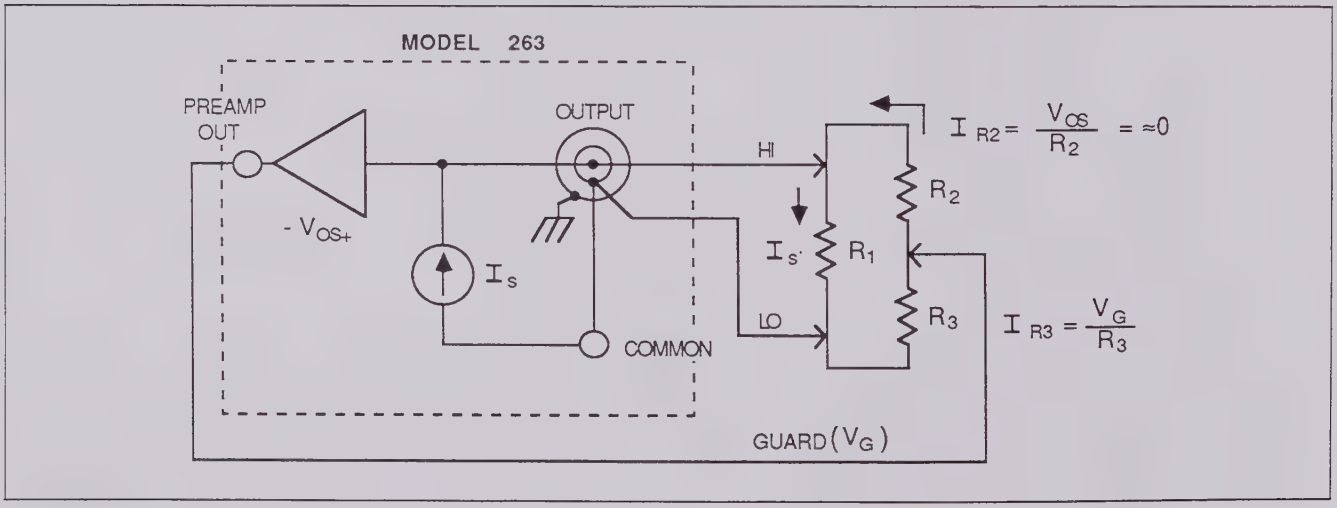


Figure 3-17. Using PREAMP OUT Guard

3.7.3 Guarded Volts

Guarding volts is unnecessary, however, the output configuration does change when GUARD is enabled (see Figure 3-18).

3.8 PREAMP OUT

When sourcing current or charge, the PREAMP OUT and COM terminals on the rear panel of the instrument can be used to monitor the voltage drop across a load. Figure 3-19 shows how PREAMP OUT is configured with the load. The preamplifier has a X1 gain, thus the voltage potential at PREAMP OUT is the same voltage dropped across the load. Using buffered PREAMP OUT minimizes loading effects that may occur if voltages were monitored at the load.

PREAMP OUT can also be used as an external guard source when sourcing current or charge. See paragraph 3.7.2 for details.

Note: Maximum current draw from PREAMP OUT is 5mA and maximum load capacitance is 10nF.

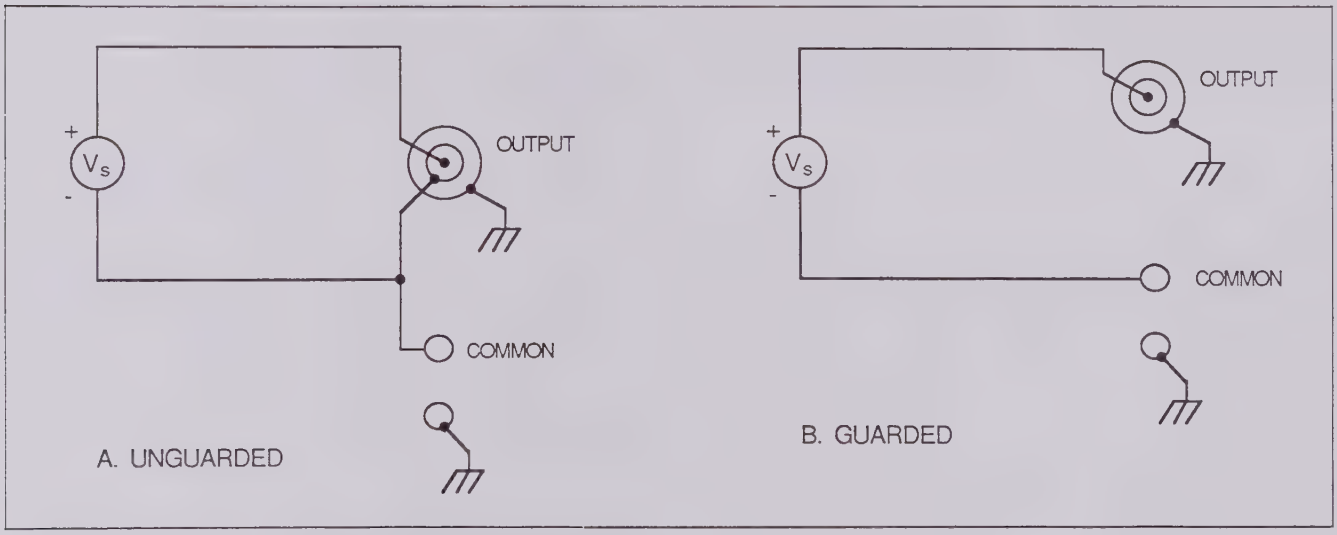


Figure 3-18. Volts Output Configuration

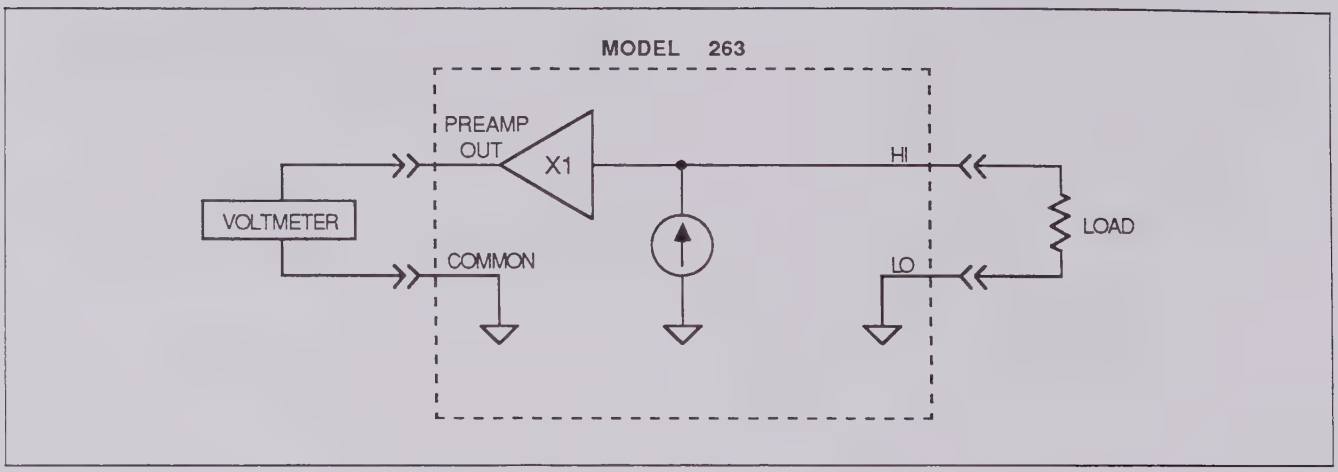


Figure 3-19. Using Preamp Out to Monitor Load Voltage

3.9 FRONT PANEL PROGRAMS

Three programs are available from the front panel: Program IEEE is used to check/change the IEEE-488 primary address of the instrument, Program dISP toggles the display reading from engineering units (e.g. mV) to scientific notation (e.g. −6), and Program tc checks/changes the status of the temperature compensation feature.

In general, a program is selected with the MENU button, modified by the ADJUST buttons, and entered again by pressing the MENU button. Detailed instructions for using these front panel programs are contained in the following paragraphs.

3.9.1 Program IEEE

The Model 263 is shipped from the factory set for an IEEE-488 primary address of 8. This program allows the user to check and/or change the address of the IEEE-488 interface. The interface can be set to any primary address from 0 to 30. Detailed information on the IEEE-488 bus is provided in Section 4. Perform the following steps to use this program:

1. Press the MENU button until the current primary address of the interface is displayed. For example, if the primary address is 8, the following message will be displayed:

   IEEE 8

2. To change the displayed address value, use the ADJUST buttons. ADJUST ▲ increments the value while ADJUST ▼ decrements the value.
3. To enter the displayed primary address, simply press MENU again. The instrument will return to normal operation and the programmed address value will be stored in memory. Thus, the instrument will power-up to the programmed primary address.

3.9.2 Program dISP

This program is used to select the alternate display mode. The Model 263 will display readings in engineering units or scientific notation. For example, a value of 100mV in the engineering units display would read 100.000mV. The same value displayed in scientific notation would read 1.00000 −1. Perform the following steps to use this program:

1. Press the MENU button until the current display mode is displayed. If the engineering units display is currently selected the following message will be displayed:

   dISP u

   If the scientific notation display is currently selected, the following message will be displayed:

   dISP −6

2. To display the alternate display mode, press any ADJUST button. These buttons toggle the display between the two modes.
3. To enter the displayed mode, again press the MENU button. The instrument will return to normal operation and the programmed display mode will be stored in memory. Thus, the instrument will power-up to the programmed display mode.

3.9.3 Program tc

This program is used to check and/or change the status of the temperature compensation feature of the Model 263. Temperature compensation is discussed in paragraph 3.11.1. Perform the following steps to use this program:

1. Press the MENU button until the status of the temperature compensation is displayed. If temperature compensation is enabled, the following message will be displayed:

   tc 1

   If temperature compensation is disabled, the following message will be dislayed:

   tc 0

2. To change the displayed status of temperature compensation press any one of the ADJUST buttons. These two buttons toggle the display between 1 and 0 (on and off).
3. To enter the displayed status of temperature compensation, again press the MENU button. The instrument will return to normal operation. Unlike the other programs, programming temperature compensation for 0 (off) will not be remembered on the next power-up. On power-up, temperature compensation will always be enabled (1).

3.10 SOURCING TECHNIQUES

Using the front panel controls has already been discussed in detail in previous paragraphs. Thus, this section will not repeat the details of performing each task required to source a particular parameter. Detailed information on function selection, range changes, data entry, guard, and zero can be found in paragraphs 3.4 through 3.8. The objective of this section is to show how all the operating tasks combine to properly source each parameter.

3.10.1 Connections

The rear panel OUTPUT connector is a Teflon® -insulated 2-lug triax receptacle intended for output signals from the Model 263. In the normal unguarded output configuration, the center terminal is high, the inner shield is low, and the outer shell is connected to instrument chassis ground (see Figure 3-20). In the guarded configuration, the inner shield is used for the guard potential and source low is connected to the COMMON terminal. With the shorting link installed, source low is routed to the outer

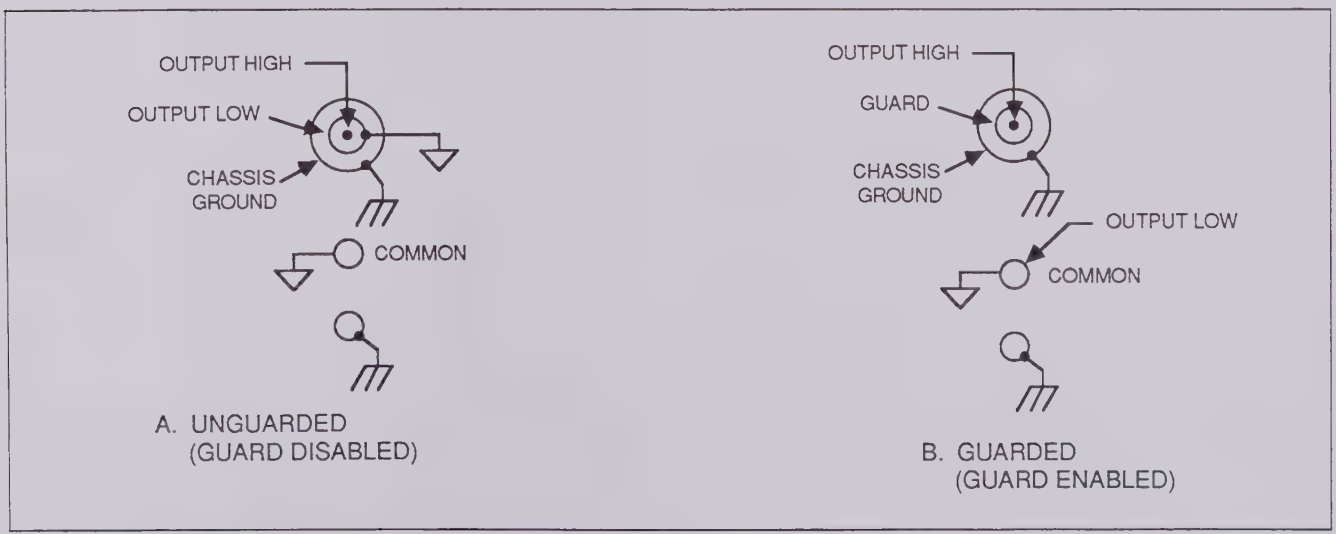


Figure 3-20. Output Connector Configuration

shell of the OUTPUT connector. Paragraph 3.7 explains how to use the guarded output of the Model 263.

For equipment that does not use triax input connectors, adapters may be needed to connect an input connector to a female triax output connector. To mate a BNC input connector to a triax output connector, attach a male BNC to a female triax adapter (Keithley Model 4804) to the BNC connector. The supplied triax cable can then be used to make the connection. To mate a UHF input connector to a triax output connector, attach a UHF-to-BNC adapter (Keithley P/N CS-115) to the UHF input connector, and attach a male BNC to female triax adapter to the BNC connector. The triax cable can then be used to make the connection.

WARNING

The maximum applied common-mode voltage (the voltage between output low and chassis ground) is 350V peak. Exceeding this value may create a shock hazard and cause damage to the instrument. If using the Model 6167 or 6191 input adapter, any applied common-mode voltage also exists between output low and its chassis.

3.10.2 Sourcing Ohms

Perform the following procedure to source ohms to an electrometer. Make sure that the electrometer is set to measure ohms and on autorange, if available. Otherwise, change ranges as required to keep the electrometer on the optimum range.

1. With the Model 263 in standby, connect the source to the electrometer. Generally, unguarded connections can be used when sourcing ≤100MΩ. For unguarded sourcing, simply connect the output of the source to the input of the electrometer as shown in Figure 3-21. Adapters for non-triax input connectors are described in paragraph 3.10.1. Guarded connections should be used for sourcing >100MΩ. Required guarding schemes are described in paragraph 3.7.1.
2. Select the ohms function by pressing the OHMS button.
3. If sourcing 1kΩ or 10kΩ, perform the following steps to cancel ZERO OFFSET test lead resistance.
   A. If autoranging is not available, set the electrometer to its lowest ohms range.
   B. Press the ZERO button on the Model 263. The display will read zero.
   C. Press OPERATE on the Model 263. Less than 1Ω will be sourced to the electrometer. The measured reading on the electrometer will be the test lead resistance and ZERO OFFSET.
   D. Zero the display of the electrometer using its zero or suppress feature.
   E. Again press ZERO to source the 1kΩ resistor. The reading on the electrometer will exclude test lead resistance and internal resistance of the source.
4. Use the the RANGE buttons to select any one of the available resistors.

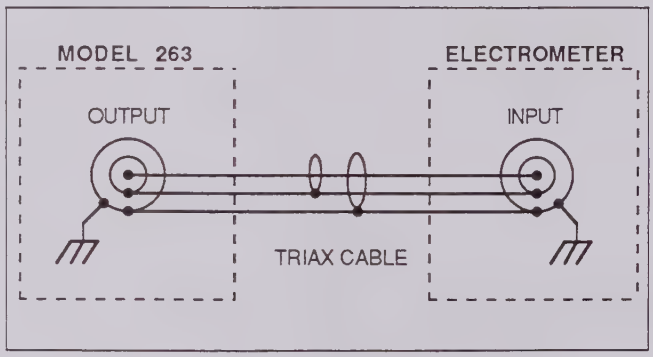


Figure 3-21. Unguarded Sourcing to Electrometer

Notes:

1. With the instrument in Operate, use the ZERO button to source zero ohms. This button toggles the output between zero and the selected output resistor.
2. In STANDBY, the 100GΩ resistor is sourced.
3. To achieve rated accuracy, do not apply more than 20V across the 1kΩ through 10GΩ resistors, or 100V across the 100GΩ resistor.
4. Additional specifications for OHMS are contained in Table 3-3.

Resistor Temperature Coefficient—The resistor temperature coefficient (TC) given in the OHMS specifications are the corrected TCs of the resistors. That is, the TCs with the Temperature Compensation feature enabled. With Temperature Compensation enabled, the Model 263 updates the display to correspond to the actual resistor value. The Model 263 does not change or correct the actual value of the resistor, it only reports the value at a given temperature. The temperature coefficient of the GΩ resistors with Temperature Compensation disabled, (no correction) is as follows:

100GΩ: 800 ppm/°C
10GΩ: 170 ppm/°C
1GΩ: 170 ppm/°C

Table 3-3. Additional Ohms Specifications

Range	Voltage Coefficient (ppm/V)	Maximum Voltage across Resistance
1 kΩ	3	20V
10 kΩ	1	30V
100 kΩ	1	50V
1MΩ	1	50V
10MΩ	1	250V
100MΩ	3	250V
1GΩ	5	250V
10GΩ	10	250V
100GΩ	100	250V

3.10.3 Sourcing Volts

The Model 263 can source up to ±19.9995V. By connecting an external voltage source to EXT INPUT, up to ±200V peak can be made available at the output. The voltage source can be used to calibrate electrometers, or connected to a load. If sourcing to an electrometer, set it on autorange, if available. Otherwise, change ranges as required to keep it on the optimum range. Perform the following procedure to use the voltage source:

1. With the Model 263 in STANDBY, connect the source to an electrometer to be calibrated or to a load. Guarded connections are not necessary when sourcing volts.
   A. If an external source is to be used, connect its output to the EXT INPUT terminals of the Model 263 as shown in Figure 3-22.

WARNING
A common-mode external voltage may be applied to the output connector. Common-mode voltage is the voltage between output low and chassis ground. A shock hazard exists if common-mode voltage exceeds 30V.

   B. To source voltage to an electrometer, connect the output of the Model 263 to the input of the electrometer as shown in Figure 3-21. If the electrometer does not have a triax input connector, an adapter will be needed (see paragraph 3.10.1.).
   C. To source voltage to a load, connect source HI to one side of the load and source LO to the other side as shown in Figure 3-23.
2. Select the volts function as follows:
   A. For normal volts, press the VOLTS button. The red VOLTS indicator will turn on.
   B. For external volts, first press SHIFT and then press VOLTS. The yellow VOLTS indicator will turn on and the message "USEr V" will be displayed. Proceed to step 5.
3. For normal volts, select the appropriate voltage range using the RANGE buttons.
4. For normal volts, enter the desired voltage reading on the display using the Adjust method or the Keypad method. In general, the Adjust method consists of positioning the cursor on the digit to be changed using the CURSOR buttons, and adjusting the display reading using the ADJUST buttons. The Keypad method consists of enabling the keypad by pressing KEYPAD/ENTER, keying in the reading using the numeric data buttons, and entering the reading by again pressing KEYPAD/ENABLE. Details on data entry can be found in paragraph 3.5.

5. If the output is connected to an electrometer, offset error of the source can be cancelled as follows:
   A. Press the ZERO button on the Model 263. The display will read zero volts.
   B. Press OPERATE on the Model 263. Zero volts will be sourced to the electrometer. The measured reading on the electrometer will be the offset of the source.
   C. Zero the display of the electrometer using zero or suppress. Subsequent voltage measurements will exclude offset error.
   D. Press OPERATE on the Model 263 to place it in standby.
   E. Press ZERO on the Model 263 to display the programmed voltage setting.
6. When ready to output the displayed voltage, press OPERATE.

Notes:

1. While in OPERATE, the ZERO button toggles the output between zero volts and the programmed voltage setting.
2. Setting the instrument to STANDBY removes the voltage source from the output and places the 100GΩ resistor on it.
3. For best accuracy, select a range that is closest to the desired output level.
4. To achieve rated accuracy, load resistance must be >100kΩ and load capacitance must be <1000pF.

3.10.4 Sourcing Amps and Coulombs

The Model 263 can source current up to ±19.9995mA and charge up to ±19.9995μC configured as an active source (AMPS or COUL) or as a passive source (AMPS V/R or COUL V/R). The difference between the active and passive (V/R) source is explained in paragraph 3.3.1. Perform the following procedure to source amps to a picoammeter or load, and coulombs to a coulombmeter. If sourcing to a picoammeter or coulombmeter, make sure it is on autorange, if available. Otherwise, change ranges as required to keep the meter on the optimum range.

1. With the Model 263 in standby, configure the equipment as follows:
   A. To source current or charge to a feedback meter, simply connect the output of the Model 263 to the input of the meter as shown in Figure 3-22. If the meter does not have a triax input connector, an adapter will be needed (see paragraph 3.10.1). Guarding is not necessary when sourcing current or charge to a feedback meter.
   B. Sourcing current or charge to a shunt meter may require guarding because of the relatively high burden voltage (typically 400mV). See paragraph 3.7.2 for guarding methods. If guarding is not going to be used, connect the source to the meter as described in step A.
   C. To source current to a load, connect the output of the Model 263 to the load as shown in Figure 3-23. If sourcing to a high impedance load, cable leakage currents may be large enough affect load current. In

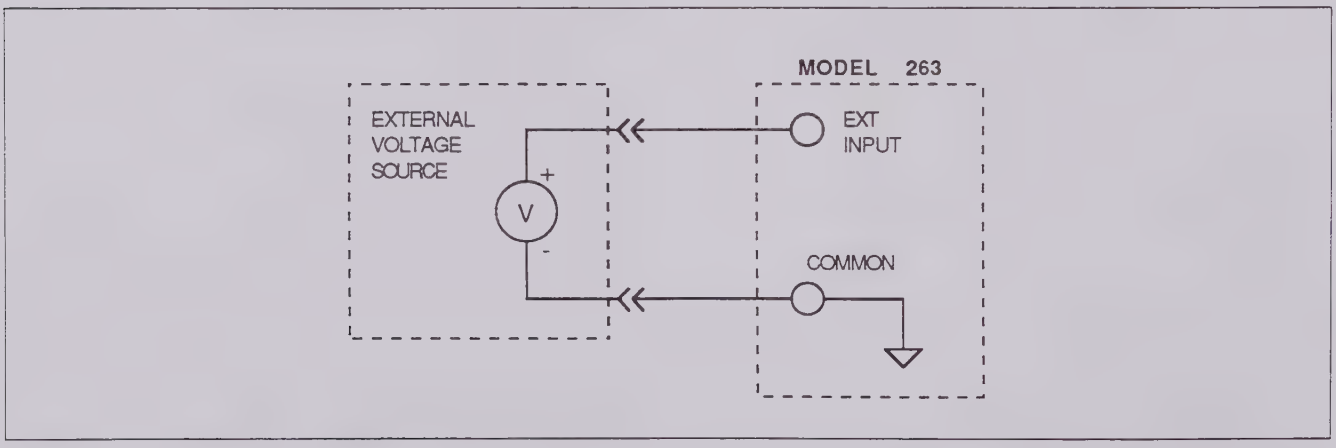


Figure 3-22. Connecting External Voltage Source to Model 263

this situation guarding will be required (see paragraph 3.7.2).

2. Select the amps or coulombs function as follows:
   A. Select an amps function as follows:
      a. For AMPS, press the AMPS button. The red AMPS light will turn on.
      b. For AMPS V/R, first press SHIFT then AMPS. The red and yellow indicator lights will turn on.
   B. Select coulombs function as follows:
      a. For COUL, press COUL. The red COUL indicator will turn on.
      b. For COUL V/R, first press SHIFT then COUL. The red and yellow indicators will turn on.
3. Select the desired range using the RANGE buttons.
4. Enter the desired current reading on the display using the Adjust method or the Keypad method. In general, the Adjust method consists of positioning the cursor on the digit to be changed using the CURSOR buttons and adjusting the display reading using the ADJUST buttons. The Keypad method consists of enabling the keypad by pressing KEYPAD/ENTER, keying in the reading using the numeric data buttons, and entering the reading by again pressing KEYPAD/ENTER. Details on data entry can be found in paragraph 3.5.
5. If the current output is connected to a picoammeter, the offset current of the source can be cancelled as follows. (Cancelling offset of the coulombs function is not recommended).
   A. Press the ZERO button on the Model 263. The display will read zero amps.
   B. Press OPERATE on the Model 263. Zero amps will be sourced to the Model 263. The measured current on the picoammeter will be the offset current.
   C. Zero the display of the picoammeter using zero or suppress. Subsequent current measurements will exclude the offset current.
   D. Press OPERATE on the Model 263 to place it in standby.
   E. Press ZERO on the Model 263 to display the programmed current setting.
6. When ready to output the displayed current or charge, press OPERATE. If in the coulombs function, charge will source for approximately one second.

Notes:

1. While in OPERATE, the ZERO button toggles the output between zero amps and the programmed current.
2. Placing the Model 263 in STANDBY:
   A. AMPS - Places the 100GΩ resistor on the output.
   B. COUL - Places zero coulombs on the output. A small charge may be measured by the electrometer because of the offset leakage current of the range. Zero check the electrometer to bleed off the charge before sourcing coulombs.
3. COULOMBS specifications require a three-second measurement interval or shorter to achieve the stated specifications. This is due to current offsets that are dependent on the leakage current of the Model 263 in COUL and with the burden voltage of the unit under test. Since charge is equivalent to Current × Time, the longer the leakage or offset current flows the greater the additional charge that will be effectively delivered to the unit under test. Below is a table listing the additional offset per second that must be added to the specifications for tests requiring measurement intervals greater than three seconds.

Additional offset for each second over three seconds

Range	Amps V/R	Amps
20pC	—	—
200pC	—	—
2nC	100fC	100fC
20nC	1pC	1pC
200nC	10pC	10pC
2 μC	100pC	100pC
20 μC	1nC	1nC

For example, if 1nC is to be output and the measurement interval is 10 seconds, the additional offset that must be added is:

$$100\text{fC} \times (10 \text{ seconds} - 3 \text{ seconds}) = 700\text{fC}$$

Generally, COUL V/R will yield better performance on the 20pC and 200pC and COUL above these ranges.

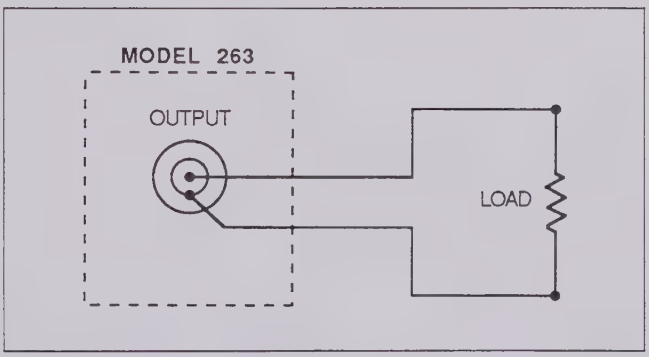


Figure 3-23. Sourcing to a Load

3.11 SOURCING CONSIDERATIONS

3.11.1 Temperature Compensation

The 1GΩ, 10GΩ and 100GΩ resistors have a high negative temperature coefficient (TC). As the temperature of the resistor rises, resistance decreases. Thus, all functions/ranges that use these resisitors are affected. Ordinarily, the change in resistance may be enough to significantly affect the output of functions/ranges that use these resistors. However, the temperature compensation feature of the Model 263 compensates for this temperature change. Table 3-4 lists the functions/ranges that are temperature compensated.

Table 3-4. Temperature Compensated Functions/ Ranges

Function	Ranges
Ohms	1GΩ, 10GΩ, 100GΩ
Amps	2nA, 200pA, 20pA, 2pA
Coulombs	2nC, 200pC, 20pC

The instrument's ability to measure the internal temperature (approximately once every second) makes temperature compensation possible. When the instrument is calibrated the resistor is measured while it is "cold" (just turned on; approximately 23°C). This reading (R_{REF}) at the "cold" temperature (T_{REF}) is remembered by the instrument. After the unit warms up, the resistor is measured (R) at the "hot" temperature (T). Because the instrument knows the change in resistance (ΔR) and the change in temperature (ΔT), it can calculate the actual TC of the resistor.

Sourcing Resistance - When sourcing resistance, the display will track the calculated output resistance. If temperature compensation is disabled by front panel Program tc (see paragraph 3.9.3), the instrument will only display the "hot" resistance value. This was the measured value (when calibrated) of the resistor after the instrument was allowed to warm up.

Sourcing Current or Charge - When sourcing current or charge, voltage changes appropriately as the resistance changes in order to maintain the output at the programmed current/charge setting. For example, on the 2nA or 2nC range the 1GΩ resistor is used. If the resistor was measured to be 1.001GΩ, the voltage source will be set to 1.001V in order to source 1nA or 1nC. If the resistance changes to 1.0007GΩ, the voltage source will change to 1.0007V to maintain the output at 1nA or 1nC. Always knowing the actual output resistance allows the instrument to adjust voltage accordingly.

If temperature compensation is disabled, the instrument will use the "hot" resistance value to calculate the voltage needed to source the programmed current or charge.

3.11.2 Burden Voltage

Burden voltage is a major consideration when sourcing passive (V/R) current or coulombs to an electrometer or picoammeter. Ideally, the input voltage burden of the meter should be zero in order for it to have no loading effect. If burden voltage is too high, its effects can degrade the source accuracy considerably.

To see how burden voltage can upset source accuracy, refer to Figure 3-24. The passive current source (AMPS V/R) of the Model 263 is shown connected to the input of an electrometer or picoammeter. The burden voltage of the meter is represented by a constant voltage source at the input as V_o . If V_o were zero, the current seen by the meter would simply be:

$$I = \frac{V_o}{R_s}$$

However, if V_o has a non-zero value, the current now becomes:

$$I = \frac{V_s - V_o}{R_s}$$

The accuracy specifications of AMPS V/R and COUL V/R include the error contributed by meters that have a burden voltage of 100μV or less. When using meters that exceed a burden voltage of 100μV, the additional sourcing error can be calculated as follows:

$$\text{Additional Error (in Amps)} = \frac{|V_o| - 100\mu V}{R_s}$$

where

R_s = The output resistance of the selected range (see Table 3-5).

I = The amps or coulombs setting on the Model 263.

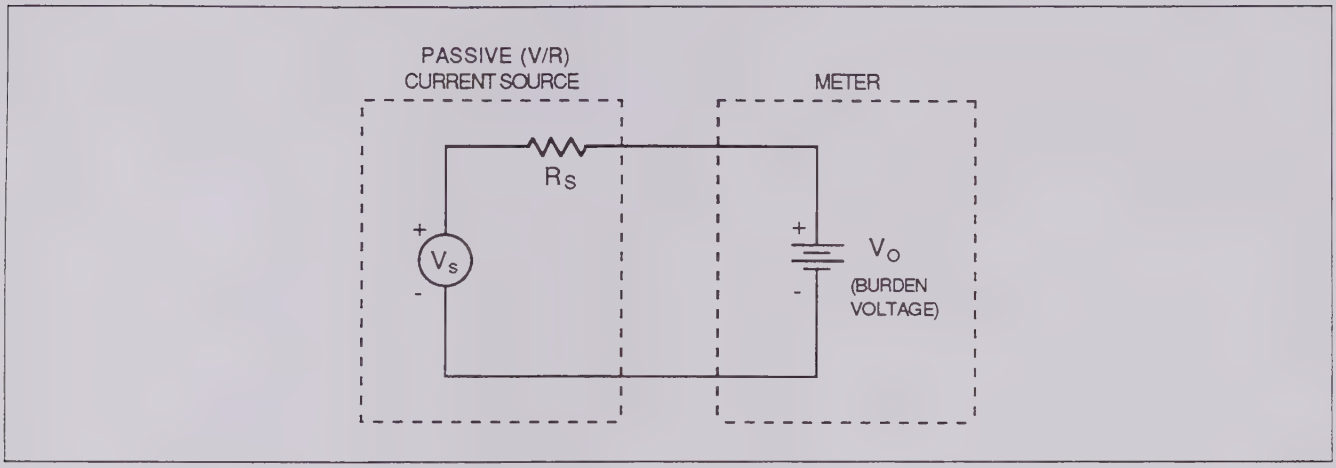


Figure 3-24. Burden Voltage Considerations

Table 3-5. Output Resistance of Passive Sources

Range		
AMPS V/R	COUL V/R	Output Resistance (R_s)
20mA	—	1 kΩ
2mA	—	10 kΩ
200 μA	—	10 kΩ
20 μA	20μC	100 kΩ
2 μA	2μC	1MΩ
200 nA	200nC	10MΩ
20 nA	20nC	100MΩ
2 nA	2nC	1GΩ
200 pA	200pC	10GΩ
20 pA	20pC	100GΩ
2 pA	—	100GΩ

The additional error is added to the basic accuracy specification. The offset specification is not affected. If the burden voltage is less than 100μV, the basic accuracy specification is not degraded.

NOTE

Adjusting the burden voltage of electrometers and picoammeters is part of their normal calibration routine. As the input voltage is adjusted to near zero, the burden voltage becomes near zero. Thus, at the time of meter calibration, burden voltage can be adjusted to be better than its specification.

3.11.3 Guarding

Guarding uses a conductor at essentially the same potential seen at output high. The guard is supplied by a low-impedance voltage source and is used to surround output high. Maintaining the guard conductor at the same potential as output high results in drastically reduced cable leakage currents.

Figure 3-25 shows the three conductors in a triax cable. Source low is normally connected to the inner shield of the cable. In this unguarded configuration, leakage current will flow through the insulator (represented by R_L and C_L) separating source HI from source LO. Whether or not this leakage current causes a problem depends on the source and the load. For the following examples, assume R_L is 100GΩ. This is the rated insulator leakage resistance of the supplied triax cable.

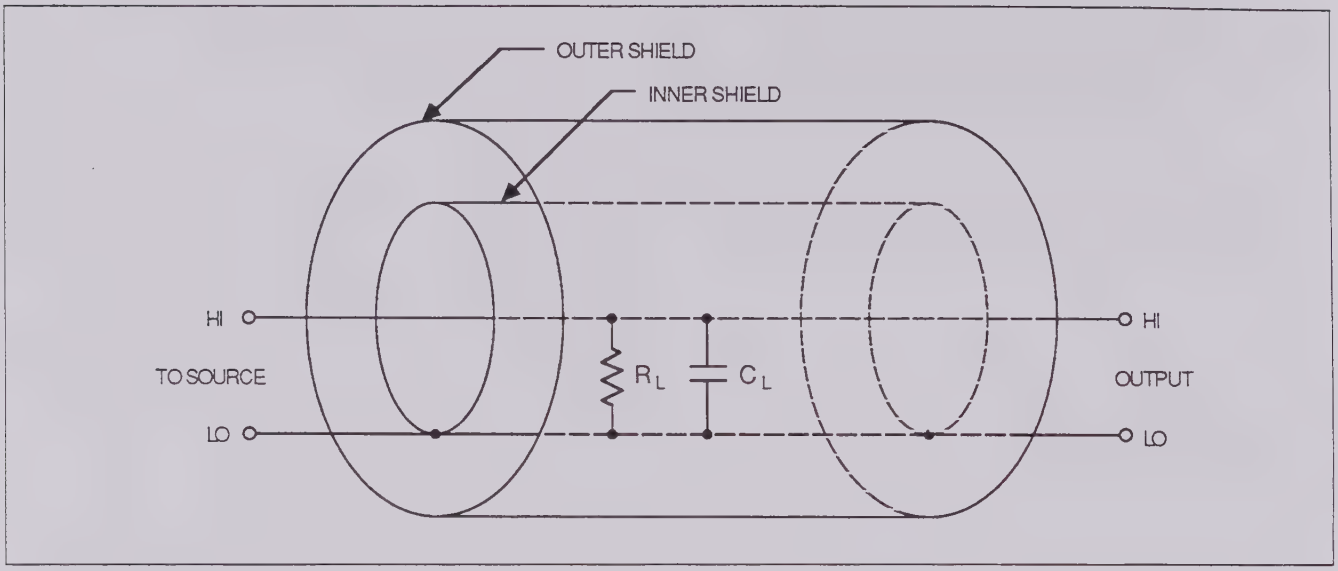


Figure 3-25. Unguarded Triax Cable

Sourcing Resistance—This example will demonstrate how cable insulator resistance affects a resistance source. The source is set to output 1GΩ to an electrometer. In the unguarded configuration, the source resistance (R_o) of 1GΩ would be in parallel with the resistance of the insulator. The resulting resistance that would be measured by the electrometer is calculated as follows:

$$R_{OUT} = \frac{R_S \times R_L}{R_S + R_L} = \frac{1G\Omega \times 100G\Omega}{1G\Omega + 100G\Omega} = \frac{100G\Omega}{101G\Omega} = 0.99G\Omega$$

Instead of delivering 1GΩ to the electrometer, only 0.99GΩ is measured at the output because of the leakage resistance. Leakage resistance contributes 1% error to the measurement.

Sourcing Current - Leakage current in an unguarded circuit is a problem when sourcing current to a high impedance load. For example, assume the source is set to output 1nA to a 1GΩ load. The 1GΩ load will be in parallel with the leakage resistance (100GΩ) resulting with ≈990pA being delivered to the load. The other 10pA will leak through the insulator. The end result is a 1% sourcing error.

Figure 3-26 shows the general technique to guard the source. Source low is rerouted to the outer shield of the cable and a guard potential (V_G) is connected to the inner shield. The guard voltage is at the same potential as source high and the guarded inner shield surrounds output high. Because the voltage potential at source high and source low is virtually the same, leakage current through the insulator will be almost zero. Generally, the guard and HI differ by a small offset voltage (≈50μV). The resultant leakage current (I_L) would be:

$$I_L = \frac{50\mu V}{100G\Omega} = 500\mu A$$

Leakage current will flow from the inner shield to the outer shield (through R_G), but it does not matter since the current is supplied by the guard source (V_G) and not source high.

While an advantage of guarding is a reduction of the effects of leakage resistance, a more important one is the reduction of the effective output capacitance (C_L). The rise time of the source depends on the output resistance and the capacitance seen at the load. Thus, for high resistance sourcing, even a small amount of cable capacitance can result in very long rise times. For example, a cable capacitance of of 1000pF and a resistance of 100GΩ will result in a RC time constant of 100 seconds. guarding would drastically reduce cable capacitance resulting in much faster rise times.

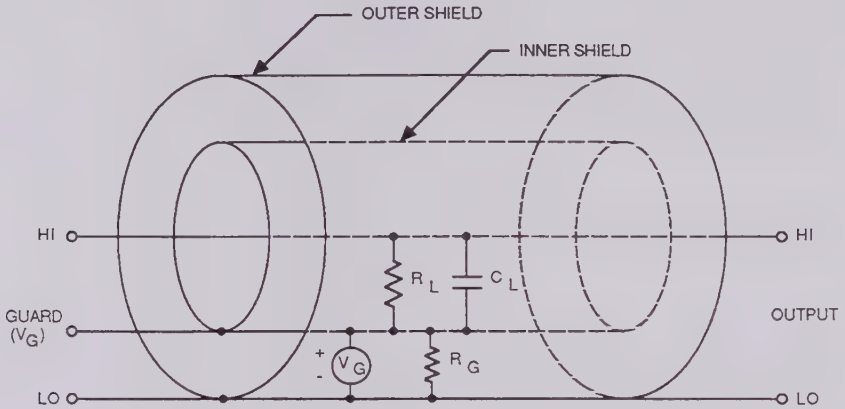


Figure 3-26. Guarded Triax Cable

SECTION 4
IEEE-488 Programming

4.1 INTRODUCTION

The IEEE-488 bus is an instrumentation data bus with hardware and programming standards originally adopted by the IEEE (Institute of Electrical and Electronic Engineers) in 1975 and given the IEEE-488 designation. In 1978, standards were upgraded into the IEEE-488-1978 standards. The Model 263 conforms to these standards.

4.2 BUS CONNECTIONS

The following paragraphs provide the detailed information needed to connect instrumentation to the IEEE-488 bus.

4.2.1 Typical Controlled Systems

System configurations are as varied as their applications. To obtain as much versatility as possible, the IEEE-488 bus was designed so that additional instrumentation could be easily added. Because of this versatility, system complexity can range from the very simple to extremely complex.

Figure 4-1 shows two possible system configurations. Figure 4-1(A) shows the simplest possible controlled system. The controller is used to send commands to the instrument, which sends data back to the controller.

The system in Figure 4-1(B) is somewhat more complex in

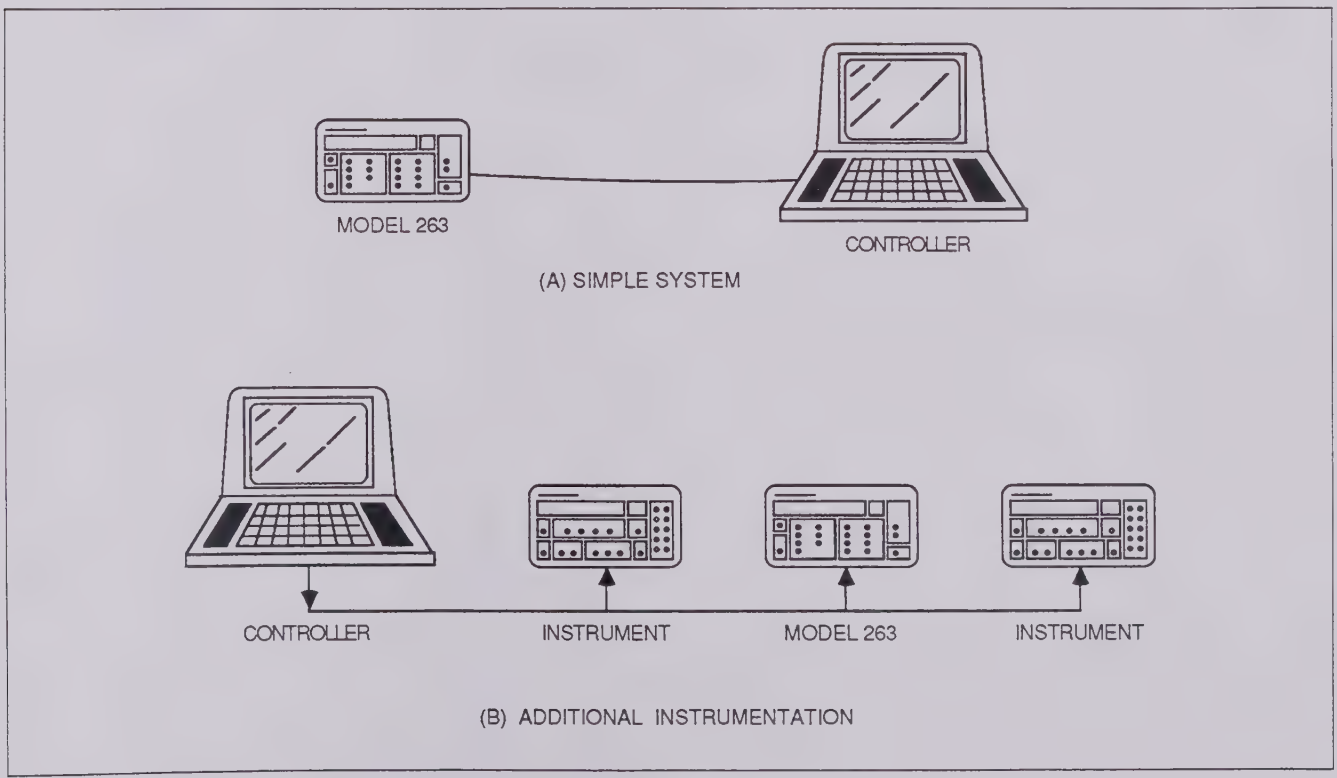


Figure 4-1. System Types

that additional instruments are used. Depending on programming, all data may be routed through the controller, or it may be sent directly from one instrument to another.

4.2.2 Cable Connections

The Model 263 is to be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors, an example of which is shown in Figure 4-2. The connector is designed to be stacked to allow a number of parallel connections. Two screws are located on each connector to ensure that connections remain secure. Current standards call for metric threads, as identified by dark colored screws. Earlier versions had different screws, which are silver colored. Do not attempt to use these type of connectors with the Model 263 which is designed for metric threads.

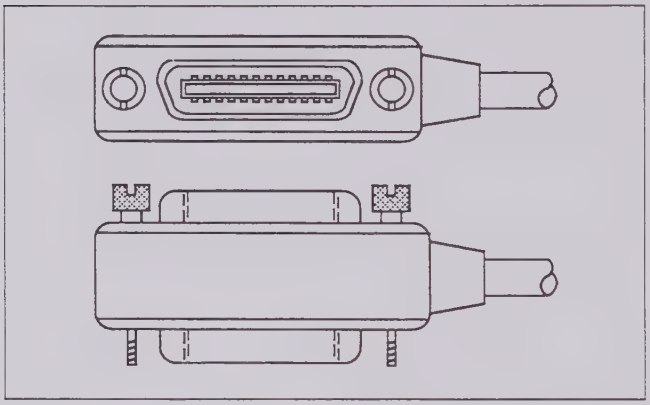


Figure 4-2. IEEE-488 Connector

A typical connecting scheme for the bus is shown in Figure 4-3 Each cable normally has the standard connector on each end. These connectors are designed to be stacked to allow a number of parallel connections on one instrument.

NOTE

To avoid possible damage, it is recommended that you stack no more than three connectors on any one instrument.

Connect the Model 263 to the cable as follows:

1. Line up the connector on the cable with the connector on the rear panel of the instrument. Figure 4-4 shows the IEEE-488 connector.
2. Tighten the screws securely, but do not overtighten them.
3. Add additional connectors from other instruments, as required.
4. Make sure the other end of the cable is properly connected to the controller. Some controllers have an IEEE-488 type connector, while others do not. Consult the instruction manual for your controller for the proper connecting method.

NOTE

The IEEE-488 bus is limited to a maximum of 15 devices, including the controller. Also, the maximum cable length is limited to 20 meters, or 2 meters times the number of devices, which ever is less. Failure to heed these limits may result in erratic bus operation.

Custom cables may be constructed by using the information in Table 4-1 and Figure 4-5. Table 4-1 lists the contact assignments for the various bus lines, while Figure 4-5 shows contact assignments.

CAUTION

The voltage between IEEE-488 common and chassis ground must not exceed 30V or instrument damage may occur.

Table 4-1. IEEE-488 Contact Designation

Number	Contact Designation	IEEE-488 Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI (24)*	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN (24)*	Management
18	Gnd, (6)*	Ground
19	Gnd, (7)*	Ground
20	Gnd, (8)*	Ground
21	Gnd, (9)*	Ground
22	Gnd, (10)*	Ground
23	Gnd, (11)*	Ground
24	Gnd, LOGIC	Ground

* Number in parenthesis refers to signal ground return of reference contact number. EOI and REN signal lines return on contact 24.

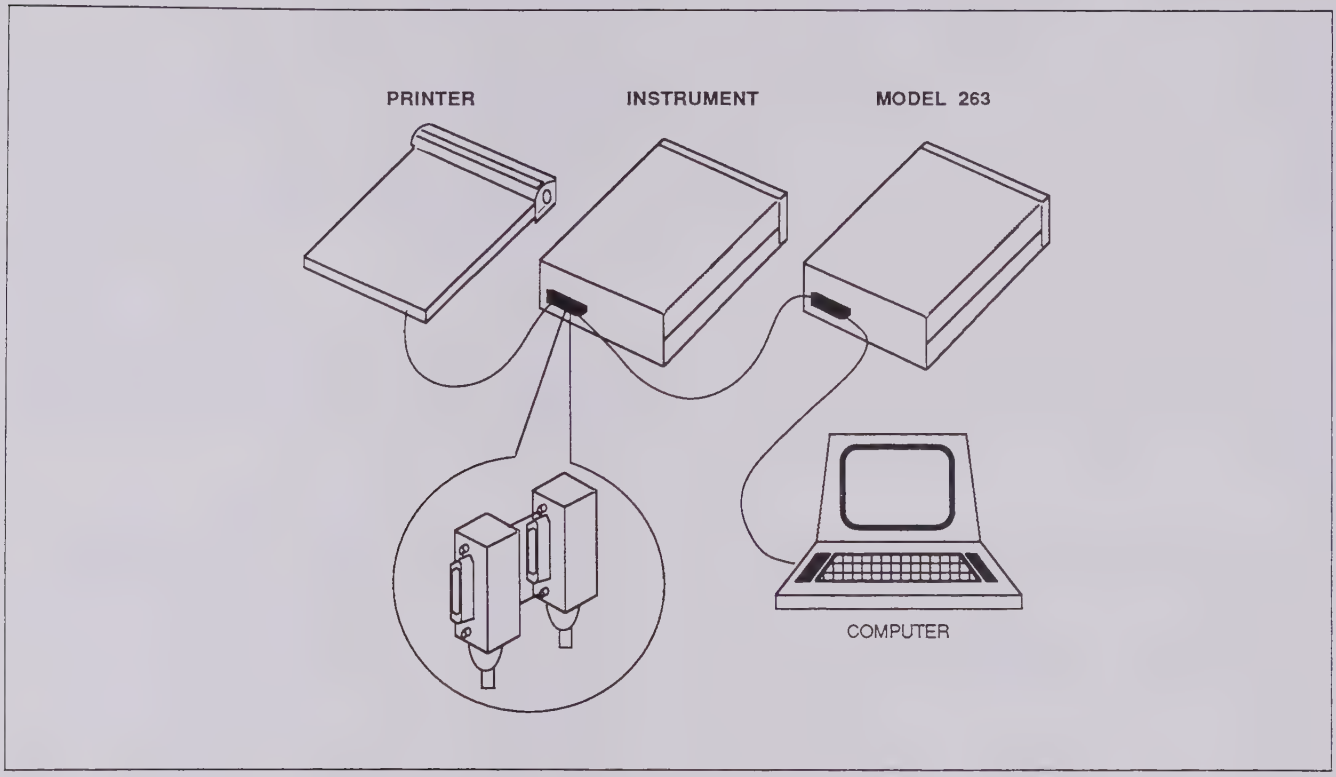


Figure 4-3. IEEE-488 Connections

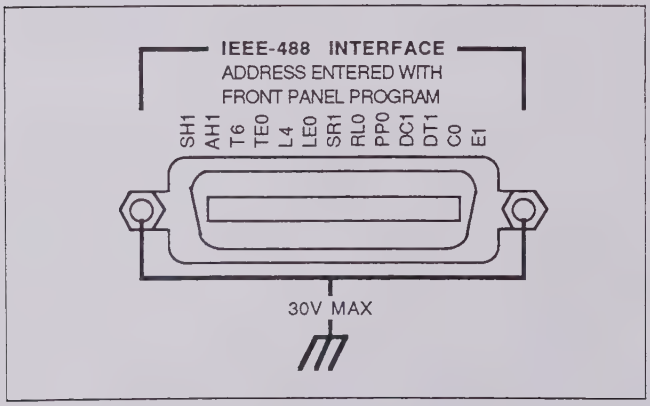


Figure 4-4. Model 263 Rear Panel IEEE-488 Connector

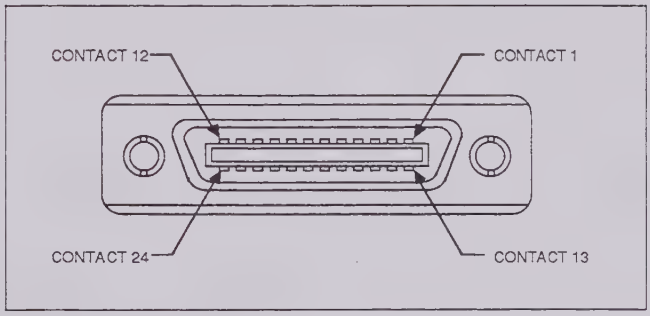


Figure 4-5. Contact Assignments

4.3 PRIMARY ADDRESS PROGRAMMING

The Model 263 must receive a listen command before it will respond to addressed commands. Similarly, the unit must receive a talk command before it will transmit its

data. The Model 263 is shipped from the factory with a programmed primary address of 8. Until you become more familiar with your instrument, it is recommended that you leave the address at this value because the programming examples included in this manual assume that address.

The primary address may be set to any value between 0 and 30 as long as address conflicts with other instruments are avoided. Note that conrollers are also given a primary address, so you must be careful not to use that address either. Most frequently, controller addresses are set to 0 or 21, but you should consult the controller's instruction manual for details. Whatever primary address you choose, you must make certain that it corresponds with the value specified as part of the controller's programming language.

To check the present primary address or to change to a new one, perform the following procedure:

1. Press the MENU button until the current primary address is displayed. For example, if the instrument is set to primary address 8, the following message will be displayed:

   IEEE 8

2. To retain the current address, press MENU until the instrument exits the front panel program mode.
3. To change the primary address, do so using the ADJUST buttons and press MENU once to exit the program mode. The new address will be stored in memory so that the instrument will power up to that address.

Note: Each device on the bus must have a unique primary address. Failure to observe this precaution will probably result in erratic bus operation.

4.4 CONTROLLER PROGRAMMING

There are a number of IEEE-488 controllers available, each of which has its own programming language. Also, different instruments have differing capabilities. In this section, we will discuss the programming language for the HP 85 computer.

NOTE

Controller programming information for using the IBM-PC interfaced through a Capital Equipment Corporation (CEC) IEEE-488 interface is located in Appendix D. See Appendix E for other controller example programs.

4.4.1 Controller Handler Software

Before a specific controller can be used over the IEEE-488 bus, it must have IEEE-488 handler software installed. With some controllers, the software is located in ROM, and no software initialization is required on the part of the user. With other controllers, software must be loaded from disk or tape and be properly initialized. With the HP-85, an additional I/O ROM that handles interface functions must be installed.

Other small computers that can be used as IEEE-488 controllers may have limited capabilities. With some, interface programming functions may depend on the interface being used. Often little software "tricks" are required to obtain the desired results.

From the preceding discussion, the message is clear: make sure the proper software is being used with the interface. Often, the user may incorrectly suspect that the hardware is causing a problem when it was the software all along.

4.4.2 Interface BASIC Programming Statements

The programming instructions covered in this section use examples written with Hewlett Packard Model 85 BASIC. This computer was chosen for these examples because of its versatility in controlling the IEEE-488 bus. This section covers those statements that are essential to Model 263 operation.

A partial list of HP-85 BASIC statements is shown in Table 4-2. HP-85 BASIC statements have a one or three digit argument that must be specified as part of the statement. The first digit is the interface select code, which is set to 7 at the factory. The last two digits of those statements, requiring a 3-digit argument, specify the primary address.

Those statements with a 3-digit argument listed in the table show a primary address of 8 (the factory default primary address of the Model 263). For a different address, you would, of course, change the last two digits to the required value. For example, to send a GTL command to a device using a primary address of 28, the following statement would be used: LOCAL 728.

Some of the statements have two forms; the exact configuration depends on the command to be sent over the bus. For example, CLEAR 7 sends a DCL command, while CLEAR 708 sends the SDC command to a device with a primary address of 8.

Table 4-2. BASIC Statements Necessary to Send Bus Commands

Action	HP-85 Statement
Transmit string to device 08.	OUTPUT 708;A$
Obtain string from device 08.	ENTER 708;A$
Send GTL to device 08.	LOCAL 708
Send SDC to device 08.	CLEAR 708
Send DCL to all devices.	CLEAR 7
Send Remote Enable.	REMOTE 708
Cancel Remote Enable.	LOCAL 7
Serial poll device 08.	SPOLL (708)
Send Local Lockout.	LOCAL LOCKOUT
Send IFC	ABORTIO 7

4.5 FRONT PANEL ASPECTS OF IEEE-488 OPERATION

The Model 263 has a number of front panel messages associated with IEEE-488 programming. These messages, which are listed in Table 4-3, are intended to inform you of certain conditions that occur when sending device-dependent commands to the instrument. The following paragraphs describe the front panel error messages associated with IEEE-488 programming.

Another front panel aspect of bus operation is local lockout (LLO). Front panel controls are functional unless the LLO command was asserted. See paragraph 4.6.3 for more information on LLO.

Table 4-3. IEEE-488 Front Panel Messages

Message	Description
bErr	Bus error, no remote, IDDC or IDDCO.
nErr	Number error. Invalid value command (A, L or V).
..	Flashing exponent decimal point(s) indicate that calibration constants were changed but not stored (temporary calibration). Also flags an NVRAM error on power up.
out	Calibration switch in disable position. Permanent storage of calibration constants (in NVRAM) not performed.
Stor	Permanent storage (in NVRAM) of cal constants performed. Calibration switch in enable position.

4.5.1 Bus Errors

A bus error will occur if the instrument receives a device-dependent command when it is not in remote, or if an illegal device-dependent command (IDDC) or illegal device-dependent command option (IDDCO) is sent to the instrument. Under these conditions, the complete command string will be rejected and the following message will be displayed:

bErr

In addition, the error bit in the serial poll byte (paragraph 4.7.9) and pertinent bits in the U1 word will be set (paragraph 4.7.12). The instrument can be programmed to generate an SRQ under these conditions.

A no remote error can occur when a command is sent to the instrument when the REN line is false. Note that the state of REN is only tested when the X character is received. An IDDC error can occur when an invalid command such as E1X is transmitted (this command is invalid because the instrument has no command associated with that letter). Similarly, an IDDCO error occurs when an invalid option is sent with a valid command. For example, the command F9X has an invalid command because the instrument has no such command option.

HP-85 Programming Example—To demonstrate a bus error, send an IDDC with the following statements:

OUTPUT 708;"E1X"

When the statement is executed, the bus error message appears on the display for about one second.

4.5.2 Number Errors

A front panel error message is used to flag a number error. A number error occurs when an out of range calibration value (A or L) or output value (V) is sent over the bus. A number error also occurs if the V command is sent while in the OHMS function. A number error will cause the value command to be ignored. However, other commands in the command sequence will be executed. The following message is displayed briefly when a number error occurs:

nErr

The instrument can be programmed to generate an SRQ

when a number error occurs (see paragraph 4.7.9).

HP-85 Programming Example—To demonstrate a number error, enter the following statements into the computer:

```
OUTPUT 708;"V100X"
```

When END LINE is pressed, a number error will occur because an output value of 100 cannot be programmed.

4.5.3 Calibration Storage Messages

There are three messages associated with storage of calibration constants.

The calibration switch must be in the ENABLED position to permanently store (in NVRAM) calibration constants. If the switch is in the DISABLE position, calibration will be temporary and will be lost when the instrument is turned off.

Storage of each calibration constant occurs automatically when a calibration value command (A or L) is sent over the bus. If a calibration value is sent with the calibration switch in the ENABLE position, the following message will be displayed briefly to indicate permanent storage:

Stor

If a calibration value is sent with the calibration switch in the DISABLE position, the following message will be displayed briefly to indicate temporary storage:

out

In addition, the exponent decimal point(s) will blink on and off to indicate that the calibration value is temporary. One exponent decimal point (i.e. "V.") blinking indicates that the L command was sent and both exponent decimal points (i.e. ".V.") indicate that the A command was sent.

NOTE

Blinking exponent decimal point(s) are also used to indicate an NVRAM failure. NVRAM is tested on power up and when the device is cleared (DCL or SDC). In the event of a failure, refer to the troubleshooting information in Section 8 of this manual.

4.6 GENERAL BUS COMMANDS

General bus commands are those commands such as DCL that have the same general meaning regardless of the instrument type. Commands supported by the Model 263 are listed in Table 4-4 which also lists BASIC statements necessary to send each command. Note that commands requiring that a primary address be specified assume that the Model 263 primary address is set to 8 (its default address).

4.6.1 REN (Remote Enable)

The remote enable command is sent to the Model 263 by the controller to set up the instrument for remote operation. Generally, the instrument should be placed in the remote mode before you attempt to program it over the bus. Simply setting REN true will not actually place the instrument in the remote mode. Instead the instrument must be addressed after setting REN true before it will go into remote.

Table 4-4. General Bus Commands and Associated BASIC Statements

Command	HP-85 Statement	Affect On Model 263
REN	REMOTE 7	Goes into remote when next addressed
IFC	ABORTIO 7	Goes into talker and listener idle states
LLO	LOCAL LOCKOUT 7	Front panel controls locked out
GTL	LOCAL 708	Cancel remote
DCL	CLEAR 7	Returns to default conditions
SDC	CLEAR 708	Returns to default conditions
	LOCAL 7	Cancel LLO

To place the Model 263 in the remote mode, the controller must perform the following sequence:

1. Set the REN line true.
2. Address the instrument to listen.

HP-85 Programming Example—This sequence is automatically performed by computer when the following is typed into the keyboard.

```
REMOTE 708
```

After the END LINE key is pressed, the instrument will be in the remote mode, as indicated by the REMOTE light. If not, check to see that the instrument is set to the proper primary address 8, and check to see that the bus connections are properly made.

4.6.2 IFC (Interface Clear)

The IFC command is sent by the controller to place the Model 263 in the local, talker and listener idle states. The unit will respond to the IFC command by cancelling front panel TALK or LISTEN lights, if the instrument was previously placed in one of those modes.

To send the IFC command, the controller need only set the IFC line true for a minimum of 100μsec.

HP-85 Programming Example—Before demonstrating the IFC command, turn on the TALK indicator with the following statements:

```
ENTER 708;A$
```

At this point, the REMOTE and TALK lights should be on. The IFC command can be sent by entering the following statement into the computer:

```
ABORTIO 7
```

After the END LINE key is pressed, the REMOTE and TALK lights will turn off, indicating that the instrument has gone into the talker idle state.

4.6.3 LLO (Local Lockout)

The LLO command is used to remove the instrument from the local operating mode. After the unit receives LLO, all its front panel controls except POWER will be inoperative. REN must be true for the instrument to respond to LLO. REN must be set false to cancel LLO.

To send the LLO command, the controller must perform the following steps:

1. Set ATN true.
2. Place the LLO command on the data bus.

HP-85 Programming Example—The LLO command is sent by entering the following statement:

```
LOCAL LOCKOUT 7
```

After the END LINE key is pressed, the instrument's front panel controls will be locked out.

4.6.4 GTL (Go To Local) and Local

The GTL command is used to take the instrument out of the remote mode. With some instruments, GTL may also cancel LLO. With the Model 263 however, REN must first be placed false before LLO will be cancelled.

To send GTL, the controller must perform the following sequence:

1. Set ATN true.
2. Address the instrument to listen.
3. Place the GTL command on the bus.

HP-85 Programming Example—Place the instrument in the remote mode with the following statement:

```
REMOTE 708
```

Now send GTL with the following statement:

```
LOCAL 708
```

When the END LINE key is pressed, the front panel REMOTE indicator goes off, and the instrument goes into the local mode. To cancel LLO, send the following:

```
LOCAL 7
```

4.6.5 DCL (Device Clear)

The DCL command may be used to clear the Model 263

and return it to its power-up default conditions. Note that the DCL command is not an addressed command, so all instruments equipped to implement DCL will do so simultaneously. When the Model 263 receives a DCL command, it will return to the power-up default conditions.

To send the DCL command, the controller must perform the following steps:

1. Set ATN true.
2. Place the DCL command byte on the data bus.

HP-85 Programming Example—Place the unit in an operating mode that is not a power-up default condition. Now enter the following statement into the computer keyboard:

```
CLEAR 7
```

When the END LINE key is pressed, the instrument returns to the power-up default conditions.

4.6.6 SDC (Selective Device Clear)

The SDC command is an addressed command that performs essentially the same function as the DCL command. However, since each device must be individually addressed, the SDC command provides a method to clear only a single, selected instrument instead of clearing all instruments simultaneously, as is the case with DCL. When the Model 263 receives the SDC command, it will return to the power-up default conditions.

To transmit the SDC command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 263 to listen.
3. Place the SDC command on the data bus.

HP-85 Programming Example—Place the unit in an operating mode that is not a power-up default condition. Now enter the following statement into the computer keyboard:

```
CLEAR 708
```

After END LINE is pressed, the instrument returns to the power-up default conditions.

4.6.7 SPE, SPD (Serial Polling)

The serial polling sequence is used to obtain the Model 263 serial poll byte. The serial poll byte contains important information about internal functions, as described in paragraph 4.7.9. Generally, the serial polling sequence is used by the controller to determine which of several instruments has requested service with the SRQ line. However, the serial polling sequence may be performed at any time to obtain the status byte from the Model 263.

The serial polling sequence is conducted as follows:

1. The controller sets ATN true.
2. The controller then places the SPE (Serial Poll Enable) command byte on the data bus. At this point, all active devices are in the serial poll mode and waiting to be addressed.
3. The Model 263 is then addressed to talk.
4. The controller sets ATN false.
5. The instrument then places its serial poll byte on the data bus, at which point it is read by the controller.
6. The controller then sets ATN true and places the SPD (Serial Poll Disable) command byte on the data bus to end the serial polling sequence.

Once instruments are in the serial poll mode, steps 3 through 5 above can be repeated by sending the correct talk address for each instrument. ATN must be true when the address is transmitted and false when the status byte is read.

HP-85 Programming Example—The SPOLL statement automatically performs the sequence just described. To demonstrate serial polling, enter in the following statements into the computer:

```
S=SPOLL (708)
DISP S
```

When the END LINE key is pressed the first time, the computer initiates the serial polling sequence. The decimal value of the serial poll byte is then displayed on the computer CRT when END LINE is pressed the second time.

MODEL 263
DEVICE-DEPENDENT COMMANDS

Execute	
X	Execute other device-dependent commands

Function	
F0	Ohms
F1	Amps
F2	Volts
F3	Coulombs
F4	V/R Amps
F5	External Volts
F6	Ladder
F7	V/R Coulombs

Range					
	Ohms	**Amps**	**Volts**	**Coul**	**Ladder**
R0	Auto On	Auto On	Auto On	Auto On	Auto On
R1	1 kΩ	2 pA	200mV	20pC	1ML
R2	10 kΩ	20 pA	2 V	200pC	10ML
R3	100 kΩ	200 pA	20 V	2nC	100ML
R4	1MΩ	2 nA	20 V	20nC	1GL
R5	10MΩ	20 nA	20 V	200nC	10GL
R6	100MΩ	200 nA	20 V	2μC	100GL
R7	1GΩ	2 μA	20 V	20μC	100GL
R8	10GΩ	20 μA	20 V	200μC	100GL
R9	100GΩ	200 μA	20 V	200μC	100GL
R10	100GΩ	2mA	20 V	200μC	100GL
R11	100GΩ	20mA	20 V	200μC	100GL
R12	Auto Off	Auto Off	Auto Off	Auto Off	Auto Off

Zero	
Z0	Zero off
Z1	Zero on

Note: The above order of presentation is the sequence that commands are executed in a command string.

Temperature Compensation	
C0	Temperature compensation off
C1	Temperature compensation on

Guard	
W0	Guard off
W1	Guard on

Self-Test	
J0	Perform self-test

Status	
U0	Send machine status word
U1	Send error conditions
U2	Send data conditions

EOI	
K0	Enable EOI
K1	Disable EOI

SRQ	
M0	Disable
M2	Charge done
M16	Ready
M32	Error

Calibration Value	
An	Calibrate using value

Calibration Value	
Ln	Calibrate low temperature cal point

Output Value	
Vn	Program output using value

Prefix	
G0	Reading with prefix
G1	Reading without prefix

Operate	
O0	Standby
O1	Operate

Terminator	
Y0	CR LF
Y1	LF CR
Y2	CR
Y3	LF
Y4	None

■ Basic programming commands used to source a parameter.

▒ Advanced programming commands.

□ Maintenance programming commands.

4.7 DEVICE-DEPENDENT COMMANDS

This section contains the information needed to control the Model 263 over the IEEE-488 bus using the device-dependent commands. A programming example using the HP-85 computer is included for each device-dependent command.

Note: It is assumed that the user is already familiar with front panel operation.

4.7.1 Programming Overview

IEEE-488 device-dependent commands (summarized in Table 4-5) are used with the Model 263 to control various operating modes such as function, range and guard. Each command is made up of a single ASCII letter followed by a number representing a command option. For example, a command to control the measuring function is programmed by sending an ASCII "F" followed by a number representing the function option. The IEEE-488 bus actually treats these commands as data in that ATN is false when the commands are transmitted.

A number of commands may be grouped together in one string. A command string is usually terminated with an ASCII "X" character, which tells the instrument to execute the command string. Commands sent without the execute character will not be executed at that time, but they will be retained within an internal command buffer for execution at the time the X character is received. If any errors occur, the instrument will display appropriate front panel error messages and generate an SRQ if programmed to do so.

Device-dependent commands affect the Model 263 much like the front panel controls. Note that commands are not necessarily executed in the order received. Thus to force a particular command sequence, you would follow each command with the execute character (X), as in the example string, Z1XF0X, which will zero the output and then select the ohms function. The order of presentation in Table 4-5 is the actual order that DDCs are executed. Note that the X command is listed first since it is the character that forces the execution of the rest of the commands.

Device-dependent commands can be sent either one at a time, or in groups of several commands within a single string. If a particular command occurs n times in a command string, then the "nth" occurrence is the only one used, e.g., F2F4F0X goes to F0X only. Some examples of valid command strings include:

F0X - Single command string.
F0K1R2X - Multiple command string.
F6 X - Spaces are ignored.

Typical invalid command strings include:

E1X - Invalid command, as E is not one of the instrument commands.
F9X - Invalid command option because 9 is not an option of the F command.

If an illegal command (IDDC) or illegal command option (IDDCO), is sent, or if a command string is sent with REN false, the string will be ignored.

Device-dependent commands that control the Model 263 are listed in Table 4-5. These commands are covered in detail in the following paragraphs. The associated programming examples show how to send the commands with the HP-85.

NOTE

Programming examples assume that the Model 263 is at its factory default value of 8. In order to send a device-dependent command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 263 to listen.
3. Set ATN false.
4. Send the command string over the bus one byte at a time.

NOTE

REN must be true when sending device-dependent commands to the instrument, or it will ignore the command and display a bus error message.

General HP-85 Programming Example—Device-dependent commands may be sent from the HP-85 with the following program:

```
10 DISP ''COMMAND STRING''
20 INPUT;A$
30 OUTPUT 708;A$
40 GOTO 10
50 END
```

When this short program is run, it will prompt you to enter a command string (line 10). If, for example, the command string F2X is entered, the instrument will go to the volts function (line 20) after END LINE is pressed. The program will then prompt for another command string.

Table 4-5. Device-Dependent Command Summary

Mode	Command	Description	Paragraph
Execute	X	Execute other device-dependent commands	4.7.15
Function	F0	Ohms	4.7.4
	F1	Amps	
	F2	Volts	
	F3	Coulombs	
	F4	V/R Amps	
	F5	External Volts	
	F6	Ladder	
	F7	V/R Coulombs	

Table 4-5. Device-Dependent Command Summary (Cont.)

Mode	Command	Description					Paragraph
Range		**Ohms**	**Amps**	**Volts**	**Coul**	**Ladder**	4.7.11
	R0	Auto On	Auto On	Auto On	Auto On	Auto On	
	R1	1 kΩ	2 pA	200mV	20pC	1ML	
	R2	10 kΩ	20 pA	2 V	200pC	10ML	
	R3	100 kΩ	200 pA	20 V	2nC	100ML	
	R4	1MΩ	2 nA	20 V	20nC	1GL	
	R5	10MΩ	20 nA	20 V	200nC	10GL	
	R6	100MΩ	200 nA	20 V	2μC	100GL	
	R7	1GΩ	2 μA	20 V	20μC	100GL	
	R8	10GΩ	20 μA	20 V	200μC	100GL	
	R9	100GΩ	200 μA	20 V	200μC	100GL	
	R10	100GΩ	2mA	20 V	200μC	100GL	
	R11	100GΩ	20mA	20 V	200μC	100GL	
	R12	Auto Off	Auto Off	Auto Off	Auto Off	Auto Off	
Zero	Z0	Zero off					4.7.17
	Z1	Zero on					
Temperature Compensation	C0	Temperature compensation off					4.7.3
	C1	Temperature compensation on					
Guard	W0	Guard Off					4.7.14
	W1	Guard On					
Self-Test	J0	Perform self-test					4.7.6
Status	U0	Send machine status word					4.7.12
	U1	Send error conditions					
	U2	Send data conditions					
EOI	K0	Enable EOI					4.7.7
	K1	Disable EOI					
SRQ	M0	Disable					4.7.9
	M2	Charge done					
	M16	Ready					
	M32	Error					
Calibration Value	An	Calibrate using value					4.7.2
Calibration Value	Ln	Calibrate temperature cal points					4.7.8
Output Value	Vn	Program output using value					4.7.13
Prefix	G0	Reading with prefix					4.7.15
	G1	Reading without prefix					
Operate	O0	Standby					4.7.10
	O1	Operate					
Terminator	Y0	CR LF					4.7.16
	Y1	LF CR					
	Y2	CR					
	Y3	LF					
	Y4	None					

4.7.2 A (Calibration)

Purpose Use to send calibration values over the bus.

Format **An**

Parameters An.nnnnnE±nn Calibration value using exponent.

Description In general, calibration of the Model 263 over the IEEE-488 bus consists of sourcing a signal to an electrometer and sending the corresponding calibration value over the bus. There are actually two calibration commands used to calibrate the Model 263; the A command and the L command. The A command is used for all but "cold" calibration of the 1GΩ, 10GΩ and 100GΩ resistors. The L command (see paragraph 4.7.8) is used to "cold" calibrate these ranges.

When calibrating VOLTS, the least significant digit (LSD) of the Model 263 display can only be zero or five. For this reason the Model 263 will round a 5½ digit A calibration command value for volts, as follows:

1. If the LSD of the command value is 1 or 2, the LSD on the display will be rounded to 0. Example: Sending A1.90252X will result in a display reading of 1.90250.
2. If the LSD of the command value is 3, 4, 6 or 7, the LSD on the display will be rounded to 5. Example: Sending A1.90254X will result in a display reading of 1.90255.
3. If the LSD of the command value is 8 or 9, the display will round to 10. That is, the LSD will be 0 and the next more significant digit will increment (carry) by one unit. Example: Sending A1.90258 will result in a reading of 1.90260.

   Note: A value cannot increment past full scale of the range it is currently on. Instead, the value will limit at 199995 counts.

Programming Notes

1. Only as many significant digits as necessary need be sent. Examples:

   Send A1.9E−9X instead of A1.9000E−09X

   Send A1.9X instead of A1.9000X
2. The instrument will ignore the digits of any calibration command value that exceeds 5½ digits. For example, if a value of 1.902587 is sent, the seven will be ignored and 1.90260 will be displayed.

Programming Examples **CAUTION: The following examples are only intended to show proper syntax. Only send calibration commands when actually calibrating the instrument. The inadvertent sending of the A command may adversely affect calibration of the Model 263. A complete IEEE-488 calibration program is contained in Section 8 (Maintenance) of this manual.**

```
OUTPUT 708;"A19.9E-12X"  ! Send cal value of 19.9 × 10^-12.
OUTPUT 708;"A2X"         ! Send cal value of 2.
```

4.7.3 C (Temperature Compensation)

Purpose Disable and enable the temperature compensation feature of the instrument.

Format **Cn**

Parameters C0 Temperature compensation disabled
C1 Temperature compensation enabled

Default Upon power up, or after a DCL or SDC command is received, temperature compensation will enable (C1).

Description The instruments ability to measure the internal operating temperature, makes it possible for it to track the actual resistance of the 1GΩ, 10GΩ and 100GΩ resistor. When the instrument is calibrated, the actual temperature coefficient of each resistor is established. The instrument can then calculate the value of each of those resistors at any temperature (see paragraph 3.11.1).

Sending C0 disables temperature compensation. With temperature compensation disabled, the instrument uses the resistor reading that was measured (during "hot" calibration) when the internal temperature approximated the normal operating temperature.

Sending C1 enables temperature compensation. With temperature compensation enabled, the instrument constantly monitors temperature and calculates the resistance of the 1GΩ, 10GΩ and 100GΩ resistors.

Programming Note If displaying the status of temperature compensation (Program tc), the display will not immediately update when the alternate C command is sent. Press the MENU button to scroll back around to Program tc to update the temperature compensation status message.

Programming Examples

```
OUTPUT 708;"C0X"  ! Disable temperature compensation
OUTPUT 708;"C1X"  ! Enable temperature compensation
```

4.7.4 F (Function)

Purpose Use to select the operating mode of the instrument.

Format **Fn**

Parameters
F0 Ohms
F1 Amps
F2 Volts
F3 Coul
F4 Amps V/R
F5 EXT INPUT
F6 Ladder
F7 Coul V/R

Description The four basic functions of the Model 263 are ohms (F0), amps, volts, and coulombs. The F1 and F3 functions use the active current source. The output accuracy of this source is not affected by burden voltage or loading, as long as compliance voltage is not surpassed. The F4 and F7 functions use the passive (V/R) current source. This current source has less offset, and is intended primarily for devices that have a very low input voltage burden. The internal voltage source (F2) is used to source up to ±19.9995V. An external source (up to 200V peak, 100mA peak) can applied to EXT INPUT on the rear panel of the Model 263. The F5 command is used to connect the external source to the output of the Model 263.

The calibration "ladder" (F6) is used to calibrate the high ohms ranges (10MΩ - 100GΩ) of the Model 263. This calibration method uses PREAMP OUT voltage readings of the Model 263 as calibration values instead of the actual resistance measurements of the resistors. This method eliminates the need for precision equipment that would be needed to accurately measure the high ohm resistors. By using the "ladder", a single precision DMM (such as the Keithley Model 196 DMM) can be used to calibrate the Model 263.

Default Upon power-up or after the instrument receives a DCL or SDC, the VOLTS function will be selected.

Programming Note Whenever an F command is sent, the instrument goes into standby.

Programming Example

```
OUTPUT 708;"F1X"   ! Select AMPS function.
```

4.7.5 G (Prefix)

Purpose Controls the format of the output string sent by the instrument.

Format **Gn**

Parameters G0 Send prefix with reading
G1 Do not send prefix with reading

Default Upon power up, or after a DCL or SDC command is received, the instrument will transmit readings with the prefix (G0).

Description The prefix identifies the reading that is sent over the bus. Figure 4.6 shows the format for these readings.

Programming Example

```
10 OUTPUT 708;"G1X"   ! Program for no prefix
20 ENTER 708;A$       ! Send reading to computer
30 DISP A$            ! Display no prefix reading on CRT
40 OUTPUT 708;"G0X"   ! Program for prefix
50 ENTER 708;A$       ! Send reading to computer
60 DISP A$            ! Display reading with prefix
```

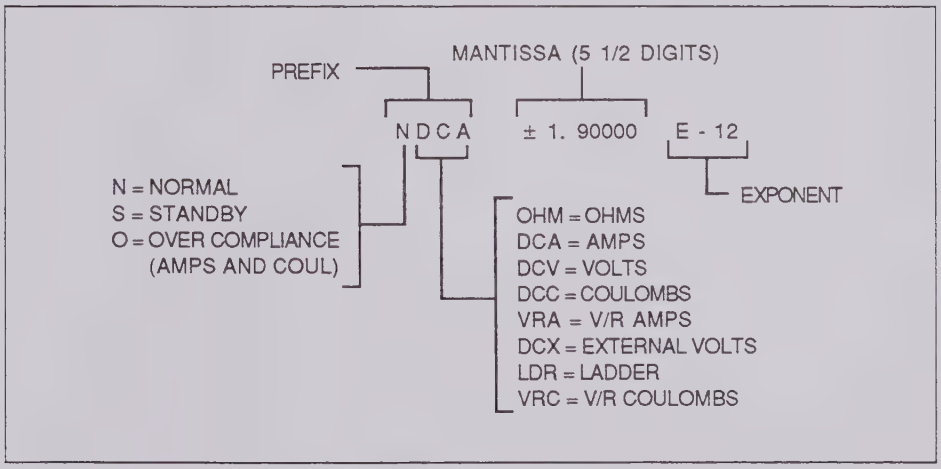


Figure 4-6. General Data Format

4.7.6 J (Self-test)

Purpose Use J command to perform tests on its read-only memory (ROM).

Format **Jn**

Parameters J0 Perform self-tests

Description Self-Test--When the J0 command is sent over the bus, the instrument performs the ROM test. If the self-test is successful, the self-test error bit in the U1 status word will be set to 0. Otherwise, a failure will set this bit to 1.

Programming Note

```
OUTPUT 708;"J0X"   ! Perform self-tests
```

4.7.7 K (EOI)

Purpose Enable/disable EOI.

Format **Kn**

Parameters
K0 EOI enabled
K1 EOI disabled

Default Upon power-up, or after the instrument receives a DCL or SDC command, the instrument will return to the K0 mode.

Description The EOI line provides one method to positively identify the last byte in the data string sent by the instrument. When enabled, EOI will be asserted with the last byte the instrument sends over the bus.

Programming Notes
1. Some controllers rely on EOI to terminate their input sequences. Suppressing EOI may cause the controller input sequence to hang.
2. When enabled, EOI will be asserted with the last byte in the terminator (if enabled), or with the last byte in the data string if the terminator has been disabled.

Programming Examples

```
OUTPUT 708;"K1X"  ! Disable EOI
OUTPUT 708;"K0X"  ! Enable EOI
```

4.7.8 L (Calibration; Low Temperature Point)

Purpose Use to send calibration values to calibrate the low (''cold'') temperature point for the 1GΩ, 10GΩ and 100GΩ resistors.

Format **Ln**

Parameters Ln.nnnnEnn Calibration value using exponent.

Description In general, each of the three gigaohm resistors are calibrated at two temperature points so that temperature coefficient (TC) profiles can be established. Because the instrument constantly measures its internal temperature and knows the actual TC of each gigaohm resistor, it can calculate the actual resistance of the resistor at any temperature. This is the temperature compensation feature of the instrument. The L command is used to send the calibration value for each of the three gigaohm resistors at the low (''cold'') temperature point. The A calibration command is used to calibrate the high (''hot'') temperature point of the gigohm resistors (see paragraph 4.7.2).

Programming Notes

1. Only as many significant digits as necessary need be sent. Example: Send L1.01E9X instead of L1.0100E09X
2. The instrument will ignore the digits of any calibration value that exceeds 5½ digits. For example, if a calibration command value of 1.882067 is sent, the seven will be ignored and 1.88206 will be displayed.

Programming Example **CAUTION: The following example is only intended to show proper syntax. Only send calibration commands when actually calibrating the instrument. The inadvertent sending of the L command may adversely affect calibration of the Model 263. A complete IEEE-488 calibration program is contained in Section 8 (Maintenance) of this manual.**

```
OUTPUT 708;''F6R4L1.88206E9X''   ! Calibrate low temperature point of 1GΩ
                                   resistor using the ''ladder''.
```

4.7.9 M (SRQ Mask and Serial Poll Byte Format)

Purpose Program which conditions will generate an SRQ (service request).

Format **Mn**

Parameters
M0 SRQ disabled
M2 Charge done
M16 Ready
M32 Error

Default Upon power up, or after the instrument receives a DCL or SDC command, SRQ is disabled (M0).

Description SRQ Mask--The Model 263 uses an internal mask to determine which conditions will cause an SRQ to be generated. Figure 4-7 shows the general format of this mask, which is made up of eight bits. The Model 263 can be programmed to generate an SRQ under one or more of the following conditions:

1. When a charge is done (M2).
2. When the instrument is ready to accept bus commands (M16).
3. When an error condition occurs (M32).

Serial Poll Byte Format--The serial poll byte contains information relating to data and error conditions within the instrument. The general format of the status byte (which is obtained by using the serial polling sequence, as described in paragraph 4.6.7) is shown in Figure 4-7. Note that the various bits correspond to the bits in the SRQ mask as described above.

The bits in the serial poll byte have the following meanings:

Bit 0 Not used; always set to zero.

Bit 1 (Charge Done) - Set when not sourcing charge. Cleared (0) while sourcing charge.

Bit 2 Not used; always set to zero.

Bit 3 Not used; always set to zero.

Bit 4 (Ready) - Set when the instrument has processed all previously received commands and is ready to accept additional commands over the bus. Cleared upon receipt of "X".

Bit 5 (Error) - Set when one of the following errors have occurred:

1. An illegal device-dependent command (IDDC) or an illegal device-dependent command option (IDDCO) was transmitted.
2. The instrument was programmed when not in remote.
3. A number error has occurred.
4. A self-test error has occurred.

This bit is cleared when the U1 status word is read to determine the type of error (see paragraph 4.7.12).

Bit 6 - Set if the Model 263 asserted SRQ. Cleared when the instrument is serial polled.

Bit 7 Not Used; always set to zero.

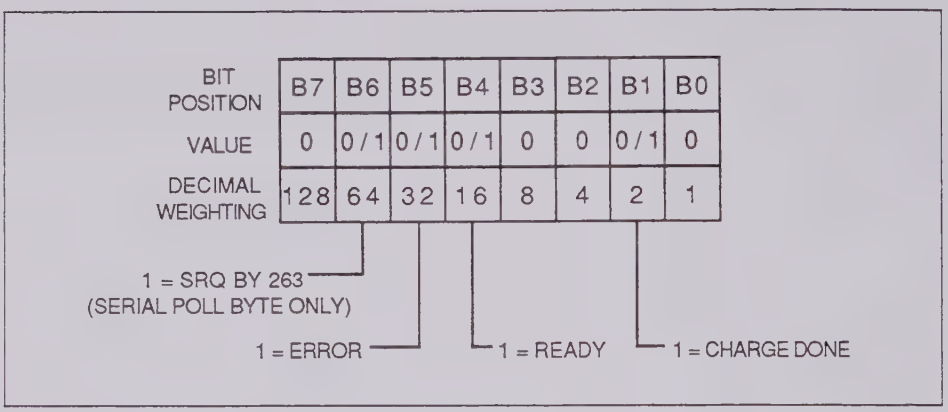

BIT POSITION
B7 B6 B5 B4 B3 B2 B1 B0
VALUE
0 0/1 0/1 0/1 0 0 0/1 0
DECIMAL WEIGHTING
128 64 32 16 8 4 2 1
1 = SRQ BY 263 (SERIAL POLL BYTE ONLY)
1 = ERROR
1 = READY
1 = CHARGE DONE

Figure 4-7. SRQ Mask and Serial Poll Byte Format

Programming Notes

SRQ Mask:

1. The instrument may be programmed to generate an SRQ for more than one set of conditions simultaneously. To do so, simply add up the decimal bit values for the required SRQ conditions. For example, to enable SRQ under charge done (M2) and error (M32) send M34X.
2. To disable SRQ, send M0X. This command will clear all bits in the SRQ mask.

Serial Poll Byte:

3. If an error occurs, bit 5 (error) in the serial poll byte will latch and remain so until the U1 word is read (paragraph 4.7.12). The U1 status word will define the nature of the error.
4. The serial poll byte should be read to clear the SRQ line once the instrument has generated an SRQ. All bits in the serial poll byte will be latched when the SRQ is generated. Bit 6 (SRQ) will be cleared when the serial poll byte is read.
5. Even with SRQ disabled, the serial poll byte can be read to determine appropriate instrument conditions. All set bits will remain latched until M0 is asserted, power is cycled, or a DCL or SDC is sent. However, bit 5 can be cleared by reading the U1 error status word.

Programming Example

```
10 OUTPUT 708;''M32X''          ! Program for SRQ on error.
20 OUTPUT 708;''E1X''           ! Attempt to program illegal com-
                                  mand (IDDC).
30 S=SPOLL(708)                 ! Serial poll the 263.
40 IF NOT BIT(S,5) THEN 30      ! Wait for SRQ to occur.
50 DISP ''B7 B6 B5 B4 B3 B2 B1  ! Label the bit positions.
   B0''
60 FOR I=7 TO 0 STEP -1         ! Loop eight times.
70 DISP BIT(S,I);               ! Display the bit positions.
80 NEXT I
90 DISP
100 END
```

4.7.10 O (Operate)

Purpose Place the instrument in operate or standby.

Format **On**

Parameters O0 Standby
O1 Operate

Default Upon power up, or after a DCL or SDC command is received, the instrument will go to standby (O0).

Description In operate (O1), the programmed source is available at the output of the Model 263.

In standby (O0), the programmed source is removed from the output. On all functions, except coulombs, the 100GΩ resistor is placed on the output. For the coulombs function, zero coulombs, on the selected range, is placed on the output.

Programming Note Anytime a function (F) command is received, the instrument will go to standby.

Programming Examples

```
OUTPUT 708;"O1X"   ! Place instrument in operate.
OUTPUT 708;"O0X"   ! Place instrument in standby.
```

4.7.11 R (Range)

Purpose Controls the sensitivity (ranges) of the source functions.

Format Rn

Parameters

	Ohms (F0)	Amps (F1, F4)	Volts (F2)	Coulombs (F3, F7)	Ladder (F6)
R0	Auto On	Auto On	Auto On	Auto On	Auto On
R1	1k	2 pA	200mV	20pC	1ML
R2	10k	20 pA	2 V	200pC	10ML
R3	100k	200 pA	20 V	2nC	100ML
R4	1M	2 nA	20 V	20nC	1GL
R5	10M	20 nA	20 V	200nC	10GL
R6	100M	200 nA	20 V	2μC	100GL
R7	1G	2 μA	20 V	20μC	100GL
R8	10G	20 μA	20 V	200μC	100GL
R9	100G	200 μA	20 V	200μC	100GL
R10	100G	2mA	20 V	200μC	100GL
R11	100G	20mA	20 V	200μC	100GL
R12	Auto Off	Auto Off	Auto Off	Auto Off	Auto Off

Default Upon power up, or after receiving a DCL or SDC command, the instrument will go to the 200mV range (R1).

Description The range command gives the user control over the sensitivity of the instrument. The F1 through F11 commands perform essentially the same functions as the front panel RANGE buttons.

An added feature available over the bus is autorange for the volts, amps and coulombs functions. When F0 is sent over the bus, autorange is selected. The range that the instrument goes to depends on the programmed value that is sent with a value command (V). The instrument will go to the lowest range (for best resolution) that can accomodate the value sent over the bus. Sending F12 over the bus disables autorange without affecting the present range.

Programming Notes

1. The instrument can be placed in autorange (R0) while on the ohms function. However, since value commands are not recognized by the ohms function, R0 has no affect on ohms range selection.
2. Sending R1 through R11 also disables autorange and places the instrument on the range that corresponds to that command option.

Programming Examples

```
OUTPUT 708;''F1R4X''      ! Select 2nA range.
OUTPUT 708;''F2R3X''      ! Select 20V range.
OUTPUT 708;''F2R0V1X''    ! Select autorange; 263 will go to 2V range.
```

4.7.12 U (Status)

Purpose Access information concerning various operating conditions of the Model 263.

Format **Un**

Parameters U0 send machine status Word
U1 send error status word
U2 send data status word

Default Upon power up, or after a DCL or SDC is received, the machine status word (U0) will default to the values shown in Figure 4-8 and the bits in the error status word (U1) will clear (0).

Description When a U command is transmitted, the instrument will transmit the appropriate status word instead of its normal data string when it is addressed to talk. The status word will be transmitted only once for each U command.

U0: The format of U0 status is shown in Figure 4-8. The letters correspond to modes programmed by the respective device-dependent commands. Returned values correspond to the programmed numeric values. The values shown in the U0 status word are the default values.

U1: The U1 command allows access to Model 263 error conditions. The error status word (Figure 4-9) is actually a string of ASCII characters representing binary bit positions. Reading the U1 status clears the error bits. An error condition is also flagged in the serial poll byte, and the instrument can be programmed to generate an SRQ when an error condition occurs (see paragraph 4.7.9).

The various bits in the U1 Error Status words are described as follows:

IDDC--Set when an illegal device-dependent command (IDDC) such as E1X is received (''E'' is illegal).

IDDCO--Set when an illegal device-dependent command option (IDDCO) such as F9X is received (''9'' is illegal).

No Remote--Set when a programming command is received when REN is false.

Number--Set when a number error occurs. A number error occurs when an invalid value (V, A or L) command is received. Also, send a V command while in OHMS will result in a number error.

Self-Test--Set when the self-test has failed.

2 6 3 F 2 R 0 0 1 Z 0 C 1 W 0 G 0 O 0 M 0 0 K 0 Y 0

MODEL NUMBER (263)

FUNCTION (F)
0 = Ohms
1 = Amps
2 = Volts
3 = Coul
4 = V/R Amps
5 = Ext Volts
6 = Ladder
7 = V/R Coul

RANGE (R)
Rmnn
m (Autorange)
0 = Autorange off
1 = Autorange on
nn (Range)

	Ohms	Amps	Volts	Coul	Ladder
01 =	1 kΩ	2 pA	200mV	20pC	1ML
02 =	10 kΩ	20 pA	2 V	200pC	10ML
03 =	100 kΩ	200 pA	20 V	2nC	100ML
04 =	1MΩ	2 nA	20 V	20nC	1GL
05 =	10MΩ	20 nA	20 V	200nC	10GL
06 =	100MΩ	200 nA	20 V	2μC	100GL
07 =	1GΩ	2 μA	20 V	20μC	100GL
08 =	10GΩ	20 μA	20 V	200μC	100GL
09 =	100GΩ	200 μA	20 V	200μC	100GL
10 =	100GΩ	2mA	20 V	200μC	100GL
11 =	100GΩ	20mA	20 V	200μC	100GL

ZERO (Z)
0 = Zero off
1 = Zero on

TEMPERATURE COMPENSATION (C)
0 = Temperature compensation off
1 = Temperature compensation on

GUARD (W)
0 = Guard off
1 = Guard on

PREFIX (G)
0 = Prefix
1 = No prefix

OPERATE (O)
0 = Standby
1 = Operate

SRQ MASK (M)
00 = Mask cleared
02 = Charge done
16 = Ready
32 = Error

EOI (K)
0 = EOI
1 = No EOI

TERMINATOR (Y)
0 = CR LF
1 = LF CR
2 = CR
3 = LF
4 = None

Figure 4-8. U0 Machine Status Word (Default Conditions Shown)

MODEL NO.	IDDC	IDDC0	NO REMOTE	NUMBER	SELF-TEST	
263	1/0	1/0	1/0	1/0	1/0	0000<TERM>

Figure 4-9. U1 Error Status Word

U2: The U2X sequence allows access to instrument data conditions. The U2 word is made up of ASCII characters representing binary values (0 or 1). The bits in the U2 status word are shown in Figure 4-10, and described as follows:

Uncalibrated. There are two situations that will cause this bit to set.

1. This bit will be set if a calibration value is sent with the calibration switch in the disable position.

2. This bit will be set if there was an NVRAM error on power up, or when DCL or SDC was sent over the bus. Calibration constants are stored in NVRAM.

Compliance Overload. Set when the voltage limit (approximately ±12V) of the current source has been reached.

Calibration Switch Enabled. Set when the calibration switch is in the enable positon.

MODEL NO.	UNCALIBRATED	COMPLIANCE OVERLOAD	CALIBRATION SWITCH ENABLED	
263	0/1	0/1	0/1	000000<TERM>

Figure 4-10. U2 Data Status Word

Programming Notes

1. The instrument will transmit the appropriate status word only once each time the corresponding U command is transmitted.
2. The bits in the U1 word will latch (1) and remain that way until the U1 word is read.
3. The programmed terminator (default CR LF) will be transmitted at the end of each status word.
4. EOI will be transmitted at the end of the status word unless disabled with the K command.
5. To make sure that correct status is transmitted, the status word should be requested as soon as possible after the command is transmitted.
6. The complete command string will be ignored if an IDDC, IDDCO or no remote error occurs. The message "bErr" is displayed when a bus error occurs.
7. Within the command string, only the command(s) causing a number error will be ignored. The message "nErr" is displayed when a number error occurs.

Programming Example

```
 10 DIM A$[50]                  ! Dimension input string.
 20 OUTPUT 708;"U0X"            ! Send U0 command.
 30 ENTER 708;A$                ! Obtain U0 status from 263.
 40 DISP A$                     ! Display U0 status word.
 50 OUTPUT 708;"U1X"            ! Send U1 command.
 60 ENTER 708;A$                ! Obtain U1 status from 263.
 70 DISP A$                     ! Display U1 status word.
 80 OUTPUT 708;"U2X"            ! Send U2 command.
 90 ENTER 708;A$                ! Obtain U2 status from 263.
100 DISP A$                     ! Display U2 status word.
110 END
```

4.7.13 V (Output Value)

Purpose Use to program the instrument to the desired output reading.

Format **Vn**

Parameters V ±n.nnnnE ±nn Output value using exponent

Description The V command is used to program the output of the volts, amps and coulombs sources. Valid values for the V command depend on the range that the instrument is on. For example, sending V3X with the instrument on the 2V range is invalid and will result in a number ("nErr") error. However, if the the instrument is in autorange (R0), any value within the output range of the function will be valid. The instrument will go to the lowest possible range that can accommodate the value sent over the bus.

The least significant digit (LSD) of the Model 263 display can only be a zero or a five. For this reason the Model 263 will round a 5½ digit V command value as follows:

1. If the LSD of the command value is a 1 or 2, the LSD on the display will be rounded to a 0. Example: Sending V1.00252X will result in a display reading of 1.00250.
2. If the LSD of the command value is a 3, 4, 6 or 7, the LSD on the display will be rounded to a 5. Example: Sending V1.00254X will result in a display reading of 1.00255.
3. If the LSD of the command value is an 8 or 9, the display will round to 10. That is, the LSD will be 0 and the next more significant digit will increment (carry) by one unit. Example: Sending V1.00258 will result in a display reading of 1.00260.
4. If a 199998 or 199999 count command value is sent, the instrument will display a 199995 count reading. The instrument cannot round up and carry because 199995 is the maximum reading that the Model 263 can display. For example, sending V1.99999X will result in a display reading of 1.99995. However, if the instrument is in autorange (R0), it will instead uprange (if not already at the highest range) and display a 20000 count reading. For example, sending R0V1.99999X, will cause the Model 263 to uprange and display a reading of 2.0000. On the highest range, the reading will limit at 199995 counts.

Programming Notes

1. Only as many significant digits as necessary need be sent. Examples:
   Send V1.9E−9X instead of V1.9000E−09X
   Send V1X instead of V1.0000X
2. The instrument will ignore the digits of any command value that exceeds 5½ digits. For example, if a value of 1.222228 is sent, the eighth will be ignored and 1.22220 will be displayed.
3. The V command will not work in the ohms function. If the V command is sent, the instrument will ignore the V command, generate a number ("nErr") error, but execute any other commands sent in the same command sequence.

4.7.14 W (Guard)

Purpose Use to enable or disable guard.

Format **Wn**

Parameters W0 Disable guard
W1 Enable guard

Default Upon power up, or after a DCL or SDC command is received, guard will disable (W0).

Description When guard is enabled (W1) the output of the Model 263 is reconfigured so that a guard drive can be placed on the inner shell of the output triax connector. Depending on the function, the guard voltage may be supplied by the Model 263 or by an external drive. See paragraph 3.7 for detailed information on guard. When guard is disabled (W0) the output is placed back in the unguarded configuration.

Programming Examples

```
OUTPUT 708;"W1X"  ! Enable guard
OUTPUT 708;"W0X"  ! Disable guard
```

4.7.15 X (Execute)

Purpose Directs the Model 263 to execute device-dependent commands received since previous "X".

Format X

Description The execute command is implemented by sending an ASCII "X" over the bus. Its purpose is to direct the Model 263 to execute other device-dependent commands such as F (function) or R (range). Usually, the execute character is the last byte in the command string (a number of commands may be grouped together into one string); however, there may be certain circumstances where it is desirable to send a command string at one time and then send the execute character later.

Programming Notes

1. Command strings sent without the execute character will be stored within an internal command buffer for later execution. When the X character is finally transmitted, the stored commands will be executed, assuming that all commands in the previous string were valid.
2. Commands are not necessarily executed in the order sent. In order to force a particular command sequence, the X character should be included after each command in the command string (see third programming example).

Programming Examples

```
OUTPUT 708;"F2X"          ! Execute single command.
OUTPUT 708;"F2R4X"        ! Execute multiple command string.
OUTPUT 708;"Z1XF2X"       ! Force command sequence.
OUTPUT 708;"O1P0F4"       ! Send string without executing.
OUTPUT 708;"X"            ! Execute previous command string.
```

4.7.16 Y (Terminator)

Purpose Use to select the ASCII terminator sequence that marks the end of the instrument's data string or status word.

Format **Yn**

Parameters
Y0 CR LF
Y1 LF CR
Y2 CR
Y3 LF
Y4 No Terminator

Default Upon power up, or after a DCL or SDC is received, the Y0 terminator (CR LF) will be selected.

Description A terminator sequence can be programmed by sending the Y command followed by an appropriate character. The default terminator sequence is the commonly used carriage return, line feed (CR LF) sequence (Y0). Selecting the wrong terminator for the controller could cause the bus to hang up.

The ASCII value of the CR character is 13, and the ASCII value of the LF character is 10.

Programming Examples

```
OUTPUT 708;"Y1X"        ! Terminate on LF CR.
OUTPUT 708;"Y0X"        ! Restore default terminator.
```

4.7.17 Z (Zero)

Purpose Use to turn the zero feature on or off.

Format **Zn**

Parameters Z0 Zero Off
Z1 Zero On

Default Upon power up or after the instrument receives a DCL or SDC command, the zero feature will be off (Z0).

Description The When the Z1 command is sent, the display will zero. If in operate, zero will be sourced to the load. The programmed reading that was displayed before sending Z1 will be remembered. Thus, when Z0 is sent, the reading that was remembered will again be displayed and sourced if in operate.

Programming Note If Z1 is sent twice or more consecutively while in the volts, amps or coulombs functions, the programmed reading will be lost. Sending Z1 the first time zeros the display and stores the programmed reading. If Z1 is sent again, the current reading, which is zero will be the reading that is stored replacing the programmed reading.

Programming Examples

```
OUTPUT 708;''F2R0V10X''    ! Program 263 for 10V.
OUTPUT 708;''Z1X''         ! Send Z1; zero display.
OUTPUT 708;''Z0X''         ! Send Z0; restore 10V reading.
```

4.8 TIMING CONSIDERATIONS

A consideration for the IEEE-488 programming is transmission times of data over the bus and the time it takes for the Model 263 to perform the tasks defined by device-dependent commands.

Listening

Typically, a command string sent to the Model 263 will transmit at a rate of one character per millisecond. For example, the command string "F1Z1O1X" will typically take 7msec to transmit from the controller to the Model 263.

The time it takes for the Model 263 to perform the tasks of the command string is typically 16msec. This is the time from "X" to "instrument configured".

Talking

When the Model 263 is sending a reading to the controller, the transmission rate will typically be one character per 0.2msec. The output of the Model 263 is refreshed once per second. Thus, the Model 263 will only place one reading per second on the bus.

SECTION 5
Applications

5.1 INTRODUCTION

The applications in this section use the Model 263 as a calibrator for calibrating Keithley electrometers and picoammeters, and as a source.

The Model 263 simplifies most elecrometer/picoammeter calibration procedures. In many cases, a single Model 263 eliminates the need for separate sources (some custom built) for voltage, current, charge and resistance.

5.1.1 Calibration Applications

Paragraphs 5.2 and 5.3 contain complete procedures for calibrating the Keithley Models 485 Picoammeter and 617 Electrometer using the Model 263. Complete, separate procedures are provided for performing digital calibration from either the front panel or over the IEEE-488 bus. Digital calibration over the IEEE-488 bus is automated using BASIC programs run by the HP 85 computer.

Paragraph 5.4 summarizes how the Model 263 can be used to calibrate the remaining Keithley picoammeter/electrometer product line. These products include the Models 480 Picoammeter, 619 Electrometer, 614 Electrometer, 642 Electrometer, 610C Electrometer, 602 Electrometer, and the 616 Electrometer.

Calibration of Keithley picoammeters and electrometers should be performed when recommended by their instruction manuals, or if the performance verification procedures in the respective instruction manuals show any to be out of specification. If any of the calibration procedures cannot be performed properly, refer to that instrument's instruction manual for troubleshooting information. If the problem persists, contact your Keithley representative or the factory for futher information.

5.1.2 Sourcing Applications

Paragraph 5.5 contains several applications using the Model 263 as a precision source. Application topics cover null detection, which includes current suppression and galvanometric measurements, low ($<100m\Omega$) resistance measurements, resistivity measurements, and diode characterization.

5.2 MODEL 485 CALIBRATION

The following paragraphs provide detailed procedures for calibrating the Model 485 Picoammeter using the Model 263 Calibrator/Source. All but one of the calibration adjustments are digital and can be done from the front panel or over the IEEE-488 bus.

To calibrate the instrument from the front panel, perform the following procedures, omitting paragraph 5.2.5. To calibrate the Model 485 over the IEEE-488 bus, perform the following procedures, omitting paragraph 5.2.4.

5.2.1 Calibration Storage Enable

The Model 485 must be in calibration storage enable to store calibration constants in NVRAM. If the instrument is not placed in this mode, subsequent calibration will be lost when the instrument is turned off. Perform the following steps to enable calibration storage.

1. If the Model 485 is presently on, turn it off.
2. While holding in the STO/CLR button, turn the instrument back on.
3. When the "CAL" message is displayed, release the STO/CLR button. The instrument will return to the normal display mode and the storing of calibration constants is now enabled.

5.2.2 Required Equipment

The following items (one of each) are necessary to calibrate the Model 485:

1. Keithley Model 263 Calibrator/Source.
2. Triax to Triax Cable (supplied with 263)
3. Keithley Model 4804 Male BNC to Female Triax Adapter.

NOTE: The following additional items will be neccesary if calibration is to be performed over the IEEE-488 bus.

4. Keithley Model 4853 IEEE-488 Interface installed in the Model 485.
5. HP 85 Computer equipped with HP 82937 GPIB Interface and I/O ROM.
6. Keithley Model 7008 IEEE cable.

5.2.3 Environmental Conditions

Calibration should be performed under laboratory conditions having an ambient temperature of 23 ±1°C and a relative humidity of less than 70%. With both the Model 485 and 263 on, allow them to warm up for one hour. If either instrument has been subjected to extreme temperature or humidity, allow at least one additional hour for the instrument to stabilize before beginning the calibration procedure.

NOTE

Calibration can be stopped at any time and only those ranges out of specification need be calibrated.

5.2.4 Front Panel Calibration

Perform the following steps to calibrate the Model 485 from the front panel:

1. On the Model 485, depress ZERO CHECK and select the 2nA range.
2. With an open input, adjust the ZERO pot for .0000 ±1 count on the display.

NOTE

If Q104, U105, R113, R114 or R115 have been replaced, the picoammeter may not zero. See paragraph 5.7 in the Model 485 Instruction Manual for the procedure to balance the input amplifier.

3. Connect the output of the Model 263 Calibrator/Source to the input of the Model 485 as shown in Figure 5-1. Make sure the calibrator is in standby.
4. On the Model 485, press the REL and LOG pushbuttons simultaneously and hold in until the message "CAL" is displayed. Release the buttons. The unit is now in the calibration mode as indicated by the "CAL" annunciator.
5. Release ZERO CHECK on the Model 485.
6. Program the Model 263 to output .00000 nA. Use the AMPS (active) current source.
7. The Model 485 may be displaying a small offset (≈1 count). To cancel this offset, press REL on the Model 485 to zero the display.
8. Program the Model 263 to output 1.90000 nA.
9. Adjust the display of the Model 485 to read 1.9000nA using the STO/CLR and RCL buttons. The STO/CLR button increments the displayed reading and the RCL button decrements the displayed reading.
10. Using Table 5-1 as a guide, repeat the basic procedure outlined in steps 5 through 9 to calibrate the rest of the current ranges of the Model 485.
11. To store calibration constants and exit the calibration mode, simultaneously press the REL and LOG buttons until the message "Stor" is displayed. If instead the message "out" is displayed, then calibration storage was not enabled as explained in paragraph 5.2.1 and calibration constants will only be valid until the Model 485 is turned off.

Table 5-1. Model 485 Range Calibration

485 Range	263 Output Current	485 Reading
2 nA	1.90000 nA	1.9000nA
20 nA	19.0000 nA	19.000 nA
200 nA	190.000 nA	190.00 nA
2 μA	1.90000 μA	1.9000 μA
20 μA	19.0000 μA	19.000 μA
200 μA	190.000 μA	190.00 μA
2mA	1.9000 mA	1.9000mA

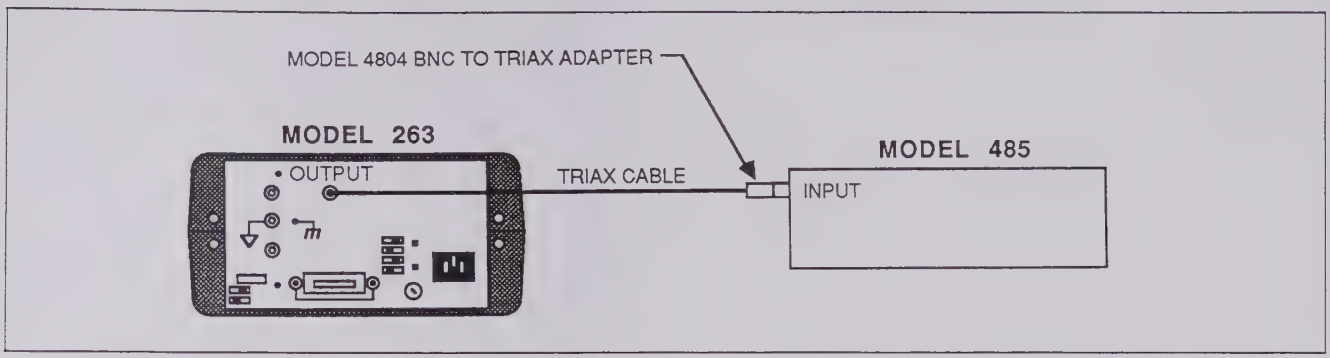


Figure 5-1. Model 485 Calibration Connections

5.2.5 IEEE-488 Bus Calibration

Perform the following steps to calibrate the Model 485 over the IEEE-488 bus using the Model 263 Calibrator/Source.

1. Connect the Models 263 and 485 to the GPIB interface of the HP 85 computer. The Model 485 must have a Model 4853 IEEE-488 Interface installed.
2. Make sure the IEEE-488 address of the Model 263 is set to 8 and the address of the Model 4853 is set to 22.
3. Enter the calibration program into the HP 85 computer.
4. To calibrate the instrument, simply press the RUN key on the computer. The program will prompt for the only manual adjustment and then automatically calibrate all the current ranges of the Model 485.
5. The program will prompt for storage of the calibration constants (line 330). This provides the user the opportunity to stop at this point to avoid permanent calibration. The calibration constants will be lost when the Model 485 is turned off.
6. Storage of calibration constants is performed on line 350 of the program and is indicated by the "Stor" message on the Model 485. If instead the message "out" is displayed, calibration storage was not enabled as explained in paragraph 5.2.1 and calibration constants will be lost when the Model 485 is turned off.
7. After calibration is completed, it is recommended that you source a current from the Model 263 to each range at ± half scale to verify accuracy.

```
10 CLEAR 722 @ CLEAR
20 WAIT 1000
30 OUTPUT 722 ;"C1R1X" ! 485; set to 2nA range and enable ZERO CHECK.
40 BEEP @ DISP "ADJUST 'ZERO' POT ON 485 FOR    .0000 +/-1 COUNT."
50 DISP
60 DISP "IF DISPLAY WILL NOT ZERO, PRO-  CEED TO PARAGRAPH 5.7 IN THE 485MANUAL.
70 DISP
80 DISP "PRESS 'CONT' KEY ON THE HP 85 TOCONTINUE."
90 PAUSE
100 CLEAR @ BEEP
110 DISP "CONNECT 263 OUTPUT TO 485 INPUT (SEE FIGURE 5-1)."
120 DISP
130 DISP "PRESS 'CONT' TO CONTINUE."
140 PAUSE
150 DATA 1,.0000000019,2,.000000019,3,.00000019,4,.0000019,5,.000019,6,.00019,7,
160 CLEAR
170 CLEAR 708
180 OUTPUT 708 ;"F1R4V1.9E-9X" ! 263; program for 1.9nA.
190 OUTPUT 722 ;"C0X" ! 485; disable ZERO CHECK.
200 FOR I=4 TO 10
210 READ J
220 OUTPUT 722 ;"R";J;"X" ! 485; select range.
230 OUTPUT 708 ;"R";I;"X" ! 263; select range.
240 OUTPUT 708 ;"Z1O1X" ! 263; output zero amps.
250 WAIT 3000
260 OUTPUT 722 ;"Z1X" ! 485; enable REL to cancel offset.
270 READ J@ WAIT 2000
280 OUTPUT 708 ;"Z0X" ! 263; source programmed output.
290 WAIT 2000
300 OUTPUT 722 ;"V";J;"X" ! 485; send calibration value.
310 OUTPUT 722 ;"Z0X" ! 485; disable REL.
320 NEXT I
330 BEEP @ DISP "TO STORE CAL CONSTANTS, PRESS   'CONT'."
340 PAUSE
350 OUTPUT 722 ;"L0X" ! 485; store cal constants.
360 CLEAR @ BEEP
370 DISP "CALIBRATION COMPLETE"
380 END
```

485 CALIBRATION PROGRAM

5.3 MODEL 617 CALIBRATION

The following paragraphs provide detailed procedures to calibrate the Model 617 using the Model 263 Calibrator/ Source. Most of the calibration procedures are digital in nature and can be done from the front panel or over the IEEE-488 bus.

To calibrate the instrument from the front panel, perform the following procedures, omitting paragraph 5.3.7. To calibrate the Model 617 over the IEEE-488 bus, perform the following procedures, omitting paragraph 5.3.6.

5.3.1 Calibration Jumper

A jumper, located on the mother board, disables/enables front panel and IEEE-488 bus calibration. When the jumper is in the disabled position, permanent (NVRAM)

storage of calibration constants will not take place. However, temporary calibration values may be entered and used even if NVRAM calibration storage is disabled. Note, however, that calibration parameters will be lost once power is turned off unless they are stored in NVRAM.

The calibration jumper location and the disabled/enabled positions are indicated in Figure 5-2.

WARNING

Turn off the instrument and disconnect the line cord before removing the top cover to reposition the calibration jumper.

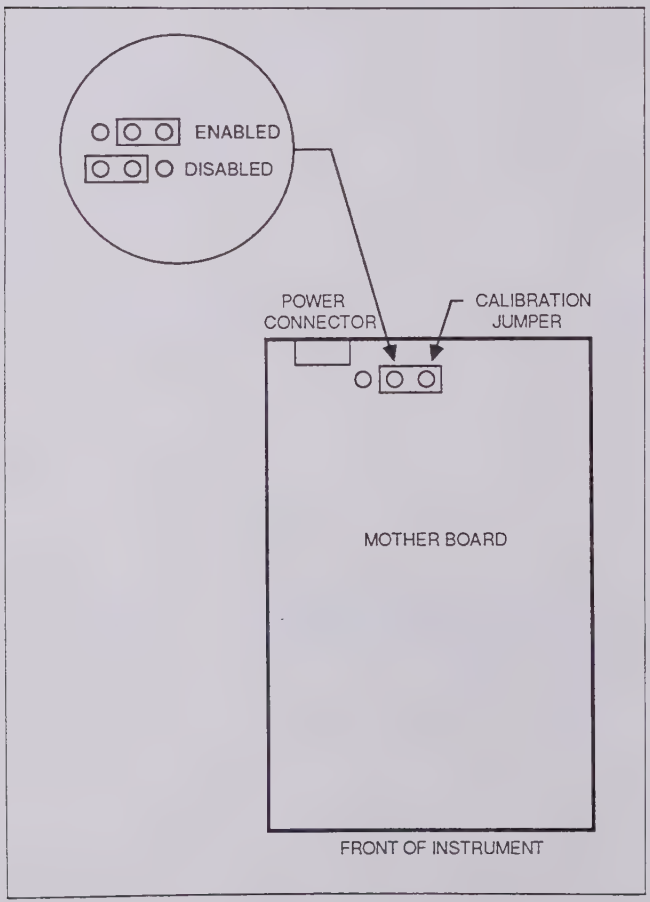


Figure 5-2. Calibration Jumper Location (Model 617)

5.3.2 Required Equipment

The following items (one of each) are necessary to calibrate the Model 617:

1. Keithley Model 263 Calibrator/Source.
2. Keithley Model 196 System DMM (±0.015%).*
3. Fluke Model 343A DC Voltage Calibrator (190V; ±0.002%).*
4. Triax-to-Triax cable (supplied with 263).
5. Keithley Model CA-18-1 Dual Banana-to-Banana cable.

NOTE: The following additional equipment will be necessary if calibration is to be performed over the IEEE-488 bus.

6. HP 85 Computer equipped with HP 82937 GPIB Interface and I/O ROM.
7. Keithley Model 7008 IEEE cable.

*Accuracy requirement of calibration equipment.

5.3.3 Environmental Conditions

Calibration should be performed under laboratory conditions having an ambient temperature of 23 ±1°C and a relative humidity of less than 70%. With both the Models 617 and 263 on, allow them to warm up for one hour. If either instrument has been subjected to extreme temperature or humidity, allow at least one additional hour for the instrument to stabilize before beginning the calibration procedure.

NOTE

While rated accuracy of the Model 617 is achieved after the two hour warm up period, input bias current may require additional time to come to its optimum level. Allow two hours for input bias current to settle to less than 10fA and eight hours to less than 5fA.

5.3.4 Calibration Sequence

Model 617 calibration must be performed in the order given in the following paragraphs, with the exception of the voltage source calibration, which can be done at any time. The basic sequence is:

Manual Adjustments:

1. Input offset adjustment
2. Input current adjustment
3. Voltage source calibration adjustments

Digital Calibration (Front Panel or IEEE-488 Bus):

4. Amps calibration
5. Coulombs calibration
6. Volts calibration
7. Ohms calibration

The voltage source is calibrated third since this is a manual adjustment. This allows the digital calibration procedures to be grouped together.

In addition to the above sequence, the ranges for each function must be calibrated in the order given. Note that you should never calibrate a range using a suppress or a zero correct value taken on a different range.

5.3.5 Manual Calibration Adjustments

After performing the following manual calibration adjustments, proceed to either front panel digital calibration (paragraph 5.3.6) or IEEE-488 Bus Digital Calibration (paragraph 5.3.7).

A. Input Offset Adjustment

Perform the following steps to null out any small offset in the input amplifier:

1. Disconnect all input signals from the Model 617.
2. Remove the two screws securing the top cover and remove the cover from the instrument.
3. Select the amps function and place the instrument on the 2pA range.
4. Enable zero check, but leave zero correct disabled.
5. Locate the offset adjustment pot (R314) on the electrometer board (see Figure 5-3). The pot is accessible through a small hole in the shield closest to the rear of the instrument.
6. Adjust R314 for a reading of 0.0000 ±1 count on the display.
7. Replace the top cover unless the following input current adjustment is to be performed.

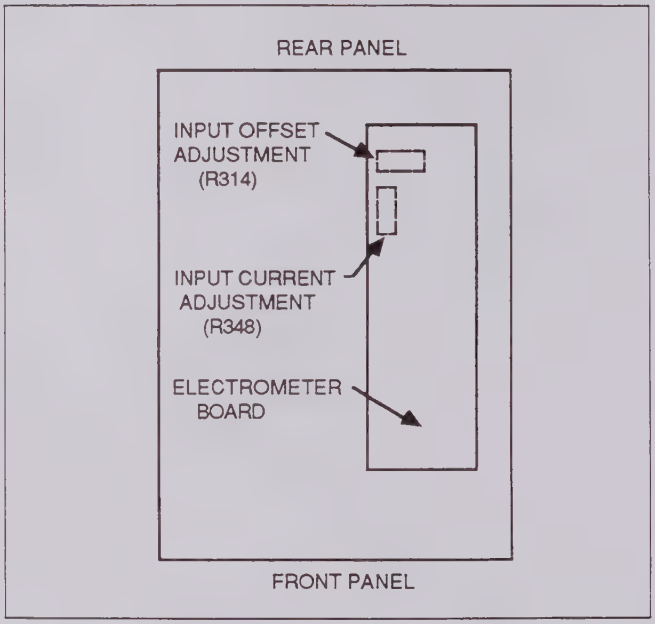


Figure 5-3. Input Offset Adjustment Locations (Model 617)

B. Input Current Adjustment

Use the following procedure to null out any input current in the input stage:

1. Disconnect all input signals from the Model 617. Place the protection cap (CAP-18) on the INPUT connector.
2. Remove the two screws securing the top cover and remove it from the instrument.
3. Place the Model 617 in the amps function and the 2pA range.
4. Enable zero check and zero correct in that order.
5. Disconnect floating sources and connect a ground link between the COM and chassis ground binding posts. Disable zero check, but leave zero correct enabled.
6. Wait several minutes until the reading on the display settles down; about 15 counts (1.5fA) p-p of noise is normal.
7. Locate the input current pot R348 on the electrometer board. It is accessible through a small hole in the shield (see Figure 5-3).
8. Carefully adjust R348 for a reading of 0.0000 ±15 counts on the display. Iterative adjustment may be necessary.
9. Replace the top cover and secure it with the two screws removed earlier.

C. Voltage Source Calibration

Use the following procedure to calibrate the voltage source. Since the voltage source is independent from the electrometer section, voltage source calibration can be performed at any time.

WARNING
Hazardous voltage will be used in some of the following steps.

1. Connect the Model 196 DMM to the voltage source output as shown in Figure 5-4.
2. From the front panel, program the voltage source of the Model 617 to 0.00V.
3. Turn on the voltage source output by pressing the OPERATE button.
4. Place the Model 196 in autorange and note the offset voltage value. A reading of 50mV or less should be displayed.
5. Press ZERO on the Model 196 to cancel the offset.
6. Program the Model 617 to output 100.00V.
7. Adjust the voltage source gain adjustment (see Figure 5-4) so that the DMM reads a voltage of 100V ±10mV.
8. Turn off the voltage source output and disconnect the DMM.

5.3.6 Front Panel Digital Calibration

Perform the following procedures to digitally calibrate the Model 617 from the front panel.

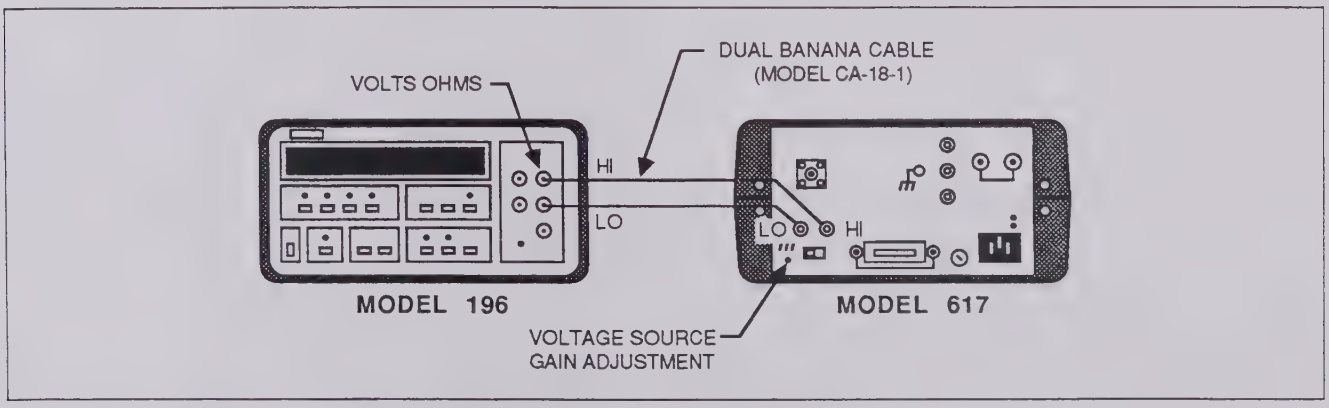


Figure 5-4. Connections for Model 617 Voltage Source Calibration

Calibration Program

The Model 617 must be placed in the calibration program in order to perform the front panel digital calibration procedures. Select the calibration program as follows:

1. Turn off the instrument for at least three seconds if it is presently turned on.
2. Press and hold the PROGRAM SELECT button and then turn on the power.
3. The instrument powers up as normal, but the CAL program is accessible in the program menu.
4. Select the calibration program by pressing PROGRAM SELECT repeatedly until the following message is displayed briefly:

   CAL

5. A normal reading will now be displayed except that the exponent decimal points will be dislayed to indicate that the instrument is in the calibration mode.

With the instrument in the calibration mode, perform the following procedures to calibrate the Model 617 from the front panel.

Amps Calibration

Calibration of the amps function should be performed in the following order: 200pA, 20nA, 20μA, and 20mA ranges. Once these ranges are calibrated, the remaining ranges are automatically calibrated. Use the AMPS (active) function of the Model 263 to source current. Proceed as follows:

1. Connect the Model 263 Calibrator/Source to the Model 617 as shown in Figure 5-5.
2. Place the Model 617 in the amps function and select the 200pA range.
3. Zero correct the Model 617 by enabling zero check and zero correct in that order.
4. Program the Model 263 to output 00.000pA and release zero check on the Model 617.
5. After allowing the reading to settle for a few seconds, zero the display of the Model 617 by pressing SUPPRESS.
6. Program the Model 263 to output 190.000pA.
7. Adjust the display of the Model 617 to read 190.00pA using the ADJUST buttons.
8. Program the Model 263 to output 00.000pA by pressing ZERO.
9. On the Model 617, disable zero correct and suppress.
10. Using Table 5-2 as a guide, select the next electrometer range and calibrator range, and repeat the basic procedure in steps 3 through 9. Calibrate all the electrometer ranges listed in the table.

Table 5-2. Model 617 Amps Calibration

617 Range	263 Output Current	617 Reading
200 pA	190.000 pA	190.00 pA
20 nA	19.0000nA	19.000nA
20 μA	19.0000 μA	19.000 μA
20mA	19.0000mA	19.000mA

Coulombs Calibration

Use the following procedure to calibrate the 20nC range. Once this range is calibrated, the two remaining ranges are automatically calibrated.

1. Connect the Model 263 Calibrator/Source to the Model 617 as shown in Figure 5-5.
2. Place the Model 617 in the coulombs function and select the 20nC range.
3. While in standby, program the Model 263 to source 19.0000nC.
4. Zero correct the Model 617 by enabling zero check with zero correct disabled. Then, enable zero correct and disable zero check. Enable suppress to null the effects of zero check hop.
5. Press the OPERATE button on the Model 263. The calibrator will source for one second.
6. Adjust the display of the Model 617 for a reading of 19.000nC using the ADJUST buttons.
7. Repeat steps 4 through 6 until the reading on the Model 617 reads 19.000nC after OPERATE is pressed on the calibrator.
8. Place the Model 617 in zero check.

Volts Calibration

Calibration of the volts function should be performed in the following order: 200mV, 2V, 20V, and 200V ranges. The 200V range will require that an external 190V source be applied to the Model 263. Proceed as follows:

1. Connect the Model 263 to the Model 617 as shown in Figure 5-5.

2. Place the Model 617 on the volts function and 200mV range.
3. Zero correct the Model 617 by enabling zero check and zero correct in that order.
4. Program the Model 263 to output 00.000mV and release zero check on the Model 617.
5. Zero the display of the Model 617 by pressing SUPPRESS.
6. Program the Model 263 to output 190.000mV.
7. Adjust the display of the Model 617 to read 190.00mV using the ADJUST buttons.
8. Program the Model 263 to output 00.000mV by pressing ZERO.
9. On the Model 617, disable zero correct and suppress.
10. Using Table 5-3 as a guide, repeat steps 3 through 9 for the 2V and 20V ranges.
11. With the Model 343A set to zero volts, connect it to the Model 263 as shown in Figure 5-6.
12. Select the 200V range and zero correct the Model 617 by enabling zero check and zero correct in that order.
13. Set the Model 343A to output 190.000V to the Model 263.
14. Release zero check on the Model 617, and program the Model 263 to output the external voltage source to the Model 617.
15. Adjust the display of the Model 617 to read 190.00V using the ADJUST buttons.
16. Place the Model 263 and the Model 343A in standby.
17. On the Model 617, disable zero correct.
18. Turn off the Model 343A and disconnect it from the Model 263.

Table 5-3. Model 617 Volts Calibration

617 Range	263 Output Voltage	External DC Calibrator Voltage	617 Reading
200mV	190.000mV	—	190.00mV
2V	1.90000V	—	1.9000V
20V	19.0000V	—	19.000V
200V	EXT VOLTS	190.000V	190.00V

Ohms Calibration

Perform the following procedure to calibrate the ohms function of the Model 617:

1. Connect the Model 263 to the Model 617 as shown in Figure 5-5. Note that Model 263 COMMON must be connected to Model 617 COMMON.
2. Enable GUARD on the Model 263 and set the Model 617 guard switch to the "ON" position.
3. Place the Model 617 in the ohms function and 2GΩ range.
4. Zero correct the Model 617 by enabling zero check and zero correct in that order.
5. Program the Model 263 to output the 1GΩ resistor. The actual value of that resistor will be displayed by the Model 263.
6. Release zero check on the Model 617 and allow the resistor reading to settle.
7. Adjust the display, using the ADJUST buttons, to correspond to the reading on the Model 263.
8. Disable guard on the Model 263 and set the Model 617 guard switch to the "OFF" position.
9. Using Table 5-4 as a guide, repeat steps 4 through 7 for the 200MΩ, 20MΩ, 2MΩ, and 200kΩ ranges.
10. Set the Model 617 to the 20kΩ range.
11. Zero correct the Model 617 by enabling zero check and zero correct in that order.
12. Set the Model 263 to the 10kW range and press ZERO to source ohms to the Model 617.
13. Release zero check on the Model 263. The reading on its display is test lead resistance and zero offset.
14. Enable suppress on the Model 617 to zero the display.
15. Press ZERO on the Model 263 to source 10kΩ to the Model 263. The actual value of that resistor will be displayed by the Model 263.
16. Adjust the displayed reading on the Model 617 to correspond to the reading on the Model 263.

Table 5-4. Model 617 Ohms Calibration

617 Range	617 Guard Switch	263 GUARD	263 Calibration Resistance* (Nominal)	617 Reading
2GΩ	ON	Enabled	1GΩ	*
200MΩ	OFF	Disabled	100MΩ	*
20MΩ	OFF	Disabled	10MΩ	*
2MΩ	OFF	Disabled	1MΩ	*
200kΩ	OFF	Disabled	100kΩ	*
20kΩ	OFF	Disabled	10kΩ	*

*Actual calibration resistance value is displayed on the Model 263.

Permanent Storage of Calibration Constants

The procedures given in the preceding paragraphs will temporarily store calibration constants in internal RAM memory and will be lost when the instrument is turned off. For calibration to be permanent, you must perform NVRAM storage. Once all points have been calibrated, press PROGRAM SELECT to exit the calibration program. Assuming that the calibration jumper is in the enable position (paragraph 5.3.1), calibration constants will be stored in NVRAM, and the following message will be displayed briefly:

Stor

Also, constants for uncalibrated ranges are derived at this point.

If the calibration jumper is in the disable position, NVRAM storage will not take place, and the following message will be displayed briefly:

Out

Only changed constants are affected with uncalibrated ranges unaffected. The new calibration constants will be used by the instrument until power is turned off. Temporary calibration is denoted by the flashing exponent decimal points.

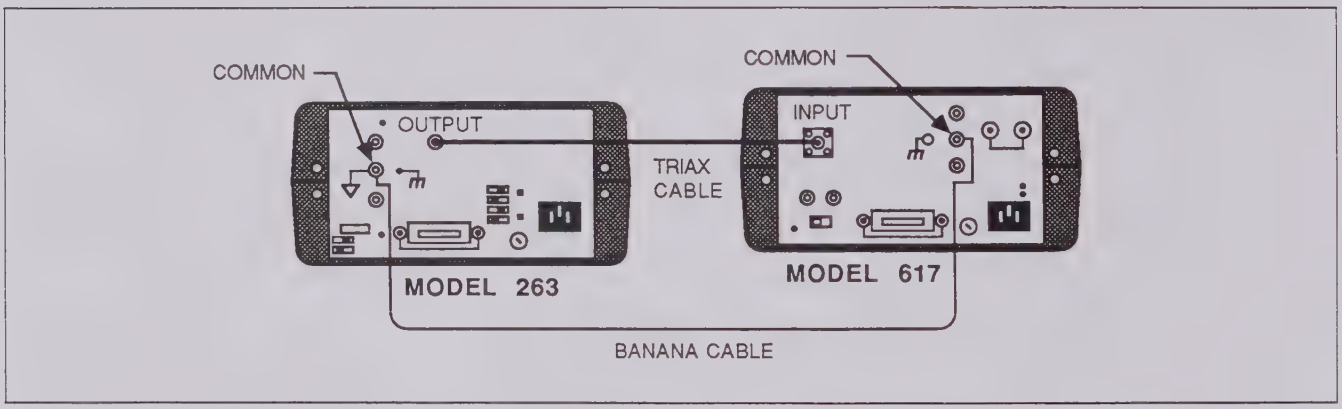


Figure 5-5. Connections for Model 617 Calibration

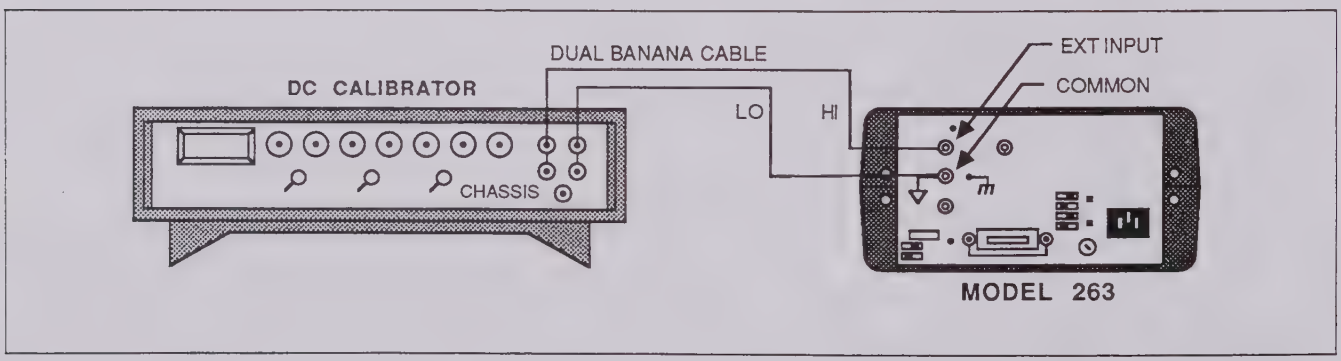


Figure 5-6. Connections for External Voltage Source

5.3.7 IEEE-488 Bus Digital Calibration

After completing the manual calibration adjustments (paragraph 5.3.5), perform the following procedure to digitally calibrate the Model 263 over the IEEE-488 bus.

1. Connect the Models 263 and 617 to the GPIB interface of the HP 85 computer.
2. Set the IEEE-488 address of the Model 263 to 8 and set the address of the Model 617 to 27.
3. Enter the calibration program into the HP 85 computer.
4. To calibrate the instrument, simply press the RUN key on the computer and follow the instructions on the CRT display.
5. After all functions are calibrated, the program will prompt for permanent storage of calibration constants in NVRAM (line 880). This provides the user the opportunity to stop at this point in order to avoid permanent calibration. The calibration constants will be lost when the instrument is turned off.
6. Storage of calibration constants into NVRAM is performed by line 940 of the program, and is indicated by the "Stor" message on the Model 617. If instead the message "out" is displayed, then the calibration jumper is in the disable position (paragraph 5.3.1) and calibration constants will be lost when the Model 617 is turned off.

```
10 CLEAR 727,708 @ CLEAR @ BEEP
20 DISP "CONNECT THE 263 TO THE 617 (FIG 5-5) AND THE EXT V-SOURCE (FIG  5-6)."
30 DISP "SET EXT V-SOURCE TO OUTPUT      190.000V TO 263." @ DISP
40 DISP "PRESS 'CONT' TO CONTINUE."
50 PAUSE
60 CLEAR
70 OUTPUT 708 ;"F1R3V190E-12X" ! 263; program for 190pA.
80 DATA 3,.00000000019,5,.000000019,8,.000019,11,.019
90 FOR I=1 TO 4
100 READ R
110 OUTPUT 727 ;"F1R";R;"X" ! 617; select I range.
120 OUTPUT 708 ;"R";R;"X" ! 263; select I range.
130 OUTPUT 708 ;"Z1O1X" ! 263; output 0A to 617.
140 WAIT 2000
150 OUTPUT 727 ;"Z1X" ! 617; zero correct display.
160 WAIT 1000
170 OUTPUT 727 ;"C0X" ! 617; disable zero check.
180 WAIT 5000
190 OUTPUT 727 ;"N1X" ! 617; zero display with suppress.
200 OUTPUT 708 ;"Z0X" ! 263; output programmed I to 617.
210 IF I>1 THEN 230
220 WAIT 15000
230 WAIT 3000
240 READ R
250 BEEP 2,200 @ OUTPUT 727 ;"A";R;"X" ! 617; send cal value.
260 WAIT 2000
270 OUTPUT 727 ;"N0Z0C1X" ! 617; disable suppress and zero correct, and enable z
280 NEXT I
290 OUTPUT 708 ;"O0X" ! 263; place in standby.
300 PRINT "AMPS RANGES CALIBRATED:"
310 PRINT "200pA, 20nA, 20uA, 20mA" @ PRINT
320 WAIT 2000 @ CLEAR
330 OUTPUT 727 ;"F3R3Z1X" ! 617; select 20nC range and zero correct display.
```

617 CALIBRATION PROGRAM

```
340 OUTPUT 708 ;"F3R4V19E-9X" ! 263; program for 19nC.
350 OUTPUT 727 ;"C0X" ! 617; disable zero check.
360 WAIT 2000
370 OUTPUT 727 ;"N1X" ! 617; enable suppress.
380 OUTPUT 708 ;"O1X" ! 263; output 20nC to 617.
390 WAIT 2500
400 BEEP 2,200 @ OUTPUT 727 ;"A19E-9X" ! 617; send cal value.
410 WAIT 2000
420 PRINT "COUL RANGES CALIBRATED:"
430 PRINT "20nC" @ PRINT
440 OUTPUT 708 ;"F2R1V190E-3X" ! 263; program for 190mV.
450 DATA .19,1.9,19
460 FOR I=1 TO 3
470 OUTPUT 727 ;"C1Z0N0F0R";I;"X" ! 617; select volts range.
480 OUTPUT 708 ;"R";I;"Z1O1X" ! 263; select range, output 0V.
490 OUTPUT 727 ;"Z1XC0X" ! 617; enable z. cor. and disable z. chk.
500 OUTPUT 727 ;"N1X" ! 617; enable suppress.
510 OUTPUT 708 ;"Z0X" ! 263; output programmed voltage.
520 READ V
530 WAIT 2000 @ CLEAR
540 BEEP 2,200 @ OUTPUT 727 ;"A";V;"X" ! 617; send cal value.
550 WAIT 2000
560 NEXT I
570 OUTPUT 727 ;"Z0N0R4X" ! 617; select 200V range.
580 OUTPUT 708 ;"F5O1X" ! 263; source ext V to 617.
590 WAIT 2000
600 BEEP 2,200 @ OUTPUT 727 ;"A190X" ! 617; send cal value.
610 WAIT 2000
620 OUTPUT 727 ;"C1F2R8X" ! 617; select 20Gohm range.
630 PRINT "VOLTS RANGES CALIBRATED:"
640 PRINT "All" @ PRINT
650 OUTPUT 708 ;"F0R8W1X" ! 263; select 10Gohm range, guard on.
660 BEEP @ DISP "SET 617 GUARD SWITCH TO 'ON'    POSITION."
670 DISP @ DISP "PRESS 'CONT' TO CONTINUE."
680 PAUSE
690 FOR I=8 TO 2 STEP -1
700 IF I=8 THEN 770
710 IF I<7 THEN 770
720 CLEAR
730 BEEP @ DISP "SET 617 GUARD SWITCH TO 'OFF'   POSITION."
740 DISP @ DISP "PRESS 'CONT' TO CONTINUE."
750 PAUSE
760 CLEAR @ OUTPUT 708 ;"W0X" ! 263; disable guard.
770 OUTPUT 708 ;"R";I;"XZ1O1X" ! 263; output 0ohms to 617.
780 OUTPUT 727 ;"C1Z0N0R";I;"X" ! 617; select range.
790 OUTPUT 727 ;"Z1XC0XN1X" ! 617; zero display.
800 OUTPUT 708 ;"Z0X" ! 263; source programmed resistance.
```

617 CALIBRATION PROGRAM (Cont.)

```
810 WAIT 7000
820 ENTER 708 ; A ! 263; send resistance reading.
830 BEEP 2,200 @ OUTPUT 727 ;"A";A;"X" ! 617;send cal value.
840 WAIT 3000
850 NEXT I
860 PRINT "OHMS RANGES CALIBRATED:"
870 PRINT "20Gohm, 2Gohm, 200Mohm, 20Mohm, 2Mohm, 200kohm, 20kohm"
880 BEEP @ DISP @ DISP "DO YOU WISH TO PERMANENTLY STORECAL CONSTANTS (Y/N)?"
890 INPUT B$
900 CLEAR @ IF B$="Y" THEN 940
910 DISP "CAL CONSTANTS NOT STORED." @ DISP
920 DISP "ALTERED RANGES TEMPORARILY CAL- IBRATED."
930 GOTO 970
940 OUTPUT 727 ;"L1X" ! 617; store cal constants.
950 DISP "IF JUMPER IN 'ENABLE' POSITION.."
960 DISP @ DISP "ALL FUNCTIONS/RANGES PERMANENTLYCALIBRATED."
970 END
```

617 CALIBRATION PROGRAM (Cont.)

5.4 CALIBRATING OTHER PICOAMMETERS/ ELECTROMETERS

In general, calibrating other instruments with the Model 263 is a simple matter of sourcing the appropriate parameter to the meter and performing the calibration adjustment. However, a technique to reduce AMPS offset on the 200pA, 20pA, and 2pA ranges should be routinely used when optimum source accuracy is required. The offset generated by these ranges are listed with the accuracy specifications of the Model 263.

With the Model 263 connected to an electrometer or picoammeter, perform the following steps to reduce Model 263 offset on the 200pA, 20pA, and 2pA AMPS ranges:

1. While in standby, program the Model 263 for the desired output.
2. Place the meter in zero check and select the optimum range for the programmed output. If the meter has a zero correct feature, use it to zero the display.
3. Set the Model 263 for zero by pressing ZERO, and source zero to the meter by pressing OPERATE.
4. Release zero check on the meter. The displayed reading on the meter is offset.
5. Using the appropriate control (ZERO, SUPPRESS, etc.), zero the display of the meter to cancel the source offset.
6. The programmed output level of the Model 263 can now be sourced to the meter by again pressing ZERO.

The above procedure only needs to be performed if the specified offset of the Model 263 is high enough to adversely affect the specified accuracy of the meter reading.

The following paragraphs summarize how the Model 263 can be used to calibrate the Keithley Models 480, 619, 614, 642, 610C, 602, and 616.

5.4.1 Model 480 Picoammeter Calibration

The Model 263 simplifies the Model 480 calibration procedure by eliminating the need for precision resistors and a DCV calibrator to form a current source. Referring to the calibration procedure found in the Model 480 Instruction Manual, use the Model 263 as follows:

1. Gain Adjustement (step e)—In this step a precision resistor and a DC calibrator are used to source current. Instead, simply use the Model 263 as a current source (190.000μA and 19.0000μA) to the 100μA and 10μA ranges of the Model 480.
2. 10nA Range Adjustment (step f)—Again, in this step a precision resisitor and a DC calibrator are used to source current. Instead, use the Model 263 to source 19.0000nA to the 10nA range of the Model 480.

To connect the Model 263 to the Model 480, refer to Figure 5-7.

5.4.2 Model 619 Electrometer Calibration

Referring to the calibration procedure found in the Model 619 Instruction Manual, use the Model 263 as follows:

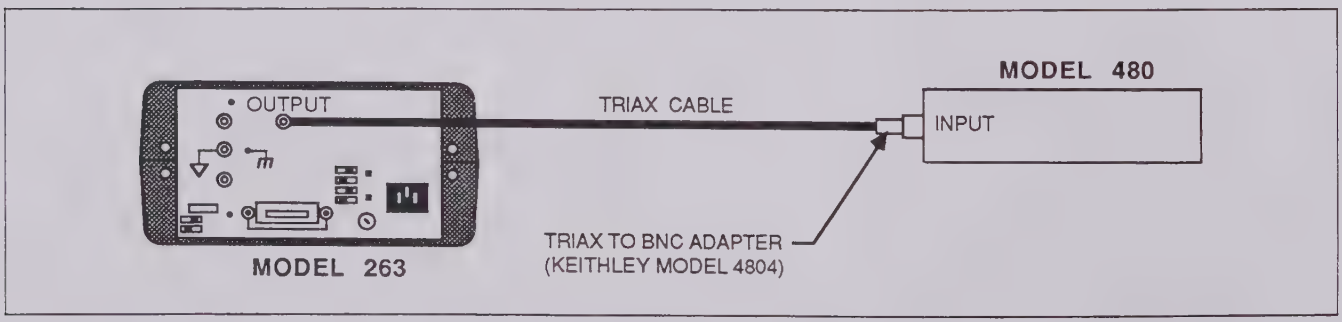


Figure 5-7. Model 480 Calibration

1. Current Range Calibration (steps 6, 7 and 8)—In these steps precision resistors (Valhalla Model 2500 Current Source and ESI Model SR-1050) and a DC calibrator (Fluke Model 343A) are used to source current. Instead, use the Model 263 to source 19mA, 190μA, 1.9μA and 19nA to the Model 619. To connect the output of the Model 263 to the input of the Model 619 use a triax cable.
2. 20kΩ Range (Ohms Reference) Calibration (step 10)—This step uses the ESI 1010 Decade resistor to source 19kΩ to the Model 619. Instead, use the Model 263 to source 10kΩ to the Model 263.
3. 20GΩ Range Calibration (steps 11 and 12)—These steps use resistors that are installed in a shielded, guarded fixture that must be built. The actual resistance of this "ohms source" is then measured by a teraohmmeter (Guildline Model 9520). A much simpler alternative is to use the Model 263 to source 10GΩ to the Model 619. The Model 263 must be in the guarded configuration and connected to the Model 619 through the Model 6191 Guarded Input Adapter (see Figure 5-8).
4. Range Verification—Use the Model 263 to verify the accuracy of the current and resistance ranges (except 2TΩ range).

Using the Model 263 as described above eliminates the need for the following equipment listed in Table 7-2 of the calibration procedure.

1. Valhalla 2500 Current Source
2. ESI 1050 Decade Resistor
3. Keithley R-289-10G Resistors (2)
4. Keithley R-289-100G Resistor
5. Guildline 9520 Teraohmmeter
6. Guarded Test Fixture

5.4.3 Model 614 Electrometer Calibration

Referring the calibration procedure in the Model 614 Instruction Manual, use the Model 263 as follows:

1. Volts Calibration (steps 6, 7 and 9)—Use the Model 263 as a voltage source in place of the Fluke 343A DC Calibrator.
2. Current and Resistance Calibration (steps 5, 6 and 7)—These steps use precision resistors (ESI DB-62) and a DC voltage calibrator (Fluke 343A) to source current. Instead, use the Model 263 to source 1.90000nA to the Model 614.

   NOTE: The Model 263 can be used to verify the accuracy of all ranges of the Model 614.

Using the Model 263 as described above eliminates the need for the Fluke 343A DC Calibrator and the ESI DB-62 Decade Resistor.

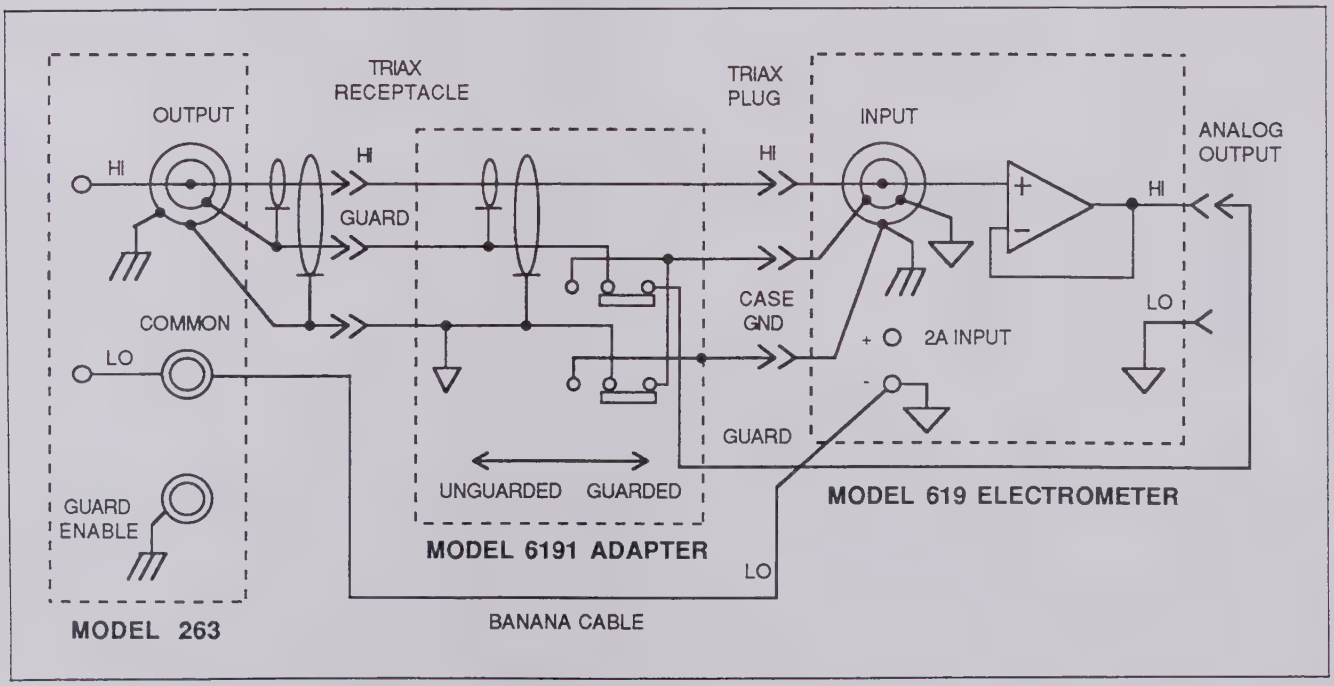


Figure 5-8. Sourcing Guarded Ohms to Electrometer Using an Input Adapter

5.4.4 Model 642 Electrometer Calibration

Referring to the calibration procedure in the Model 642 Instruction Manual, use the Model 263 as follows. Figure 5-9 shows how to connect the Model 263 to the Model 642.

1. Current Sources (pargraphs 6-12 through 6-17)—These paragraphs describe methods to generate the required current levels. These methods include using a precision resistor in series with a DC voltage calibrator and the building of a ramp generator for the lower current ranges. A much simpler method is to use the passive (V/R) current source of the Model 263.
2. Voltage Calibration (steps e, h and k)—These steps use a DC voltage calibrator (Fluke 341A) to source voltage. Instead use the voltage source of the Model 263 to source 190.000mV, 1.90000V and 10.0000V to the Model 642.
3. Current Calibration (steps b, e and g)—Use the passive (V/R) current source of the Model 263 to source 100.000nA, 1.00000nA, 100.000pA and 10.0000pA to the Model 642.
4. 1% Settling Time Adjust (step d)—Use the passive (V/R) current source of Model 263 to source 10.0000pA to the Model 642.

Using the Model 263 as described above eliminates the need for the following equipment:

1. Keithley 6426 Sapphire-Insulated Test Box
2. Gen Rad 1403B 100pF Air Capacitor
3. Fluke 341A DC Calibrator
4. Gen Rad 776-9702 BNC-to-Airline Cable
5. Keithley 6425 Airline Input Adapter
6. 100kΩ Resistor (shielded)
7. 10MΩ Resistor
8. Ramp Generator (custom built)

5.4.5 Model 610C Electrometer Calibration

There are no adjustments involved in calibrating the ranges of the Model 610C. Instead calibration consists of checking range accuracy and replacing the defective components (usually resistors out of specification).

Referring to the calibration procedure in the Model 610C Instruction Manual, use the Model 263 to check range accuracies of the electrometer. Connect the Model 263 to the Model 610C as shown in Figure 5-10.

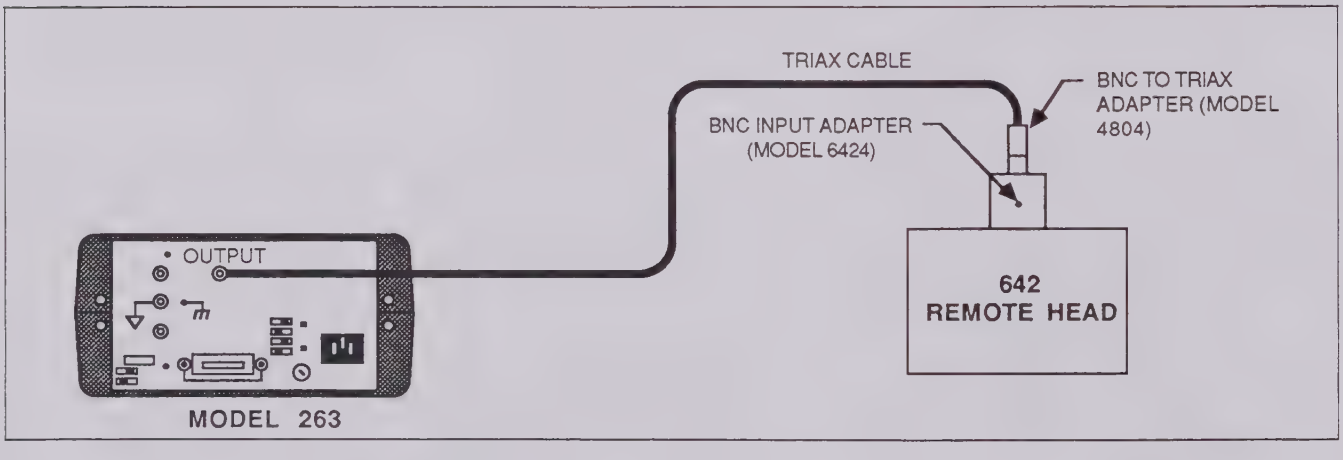


Figure 5-9. Model 642 Calibration

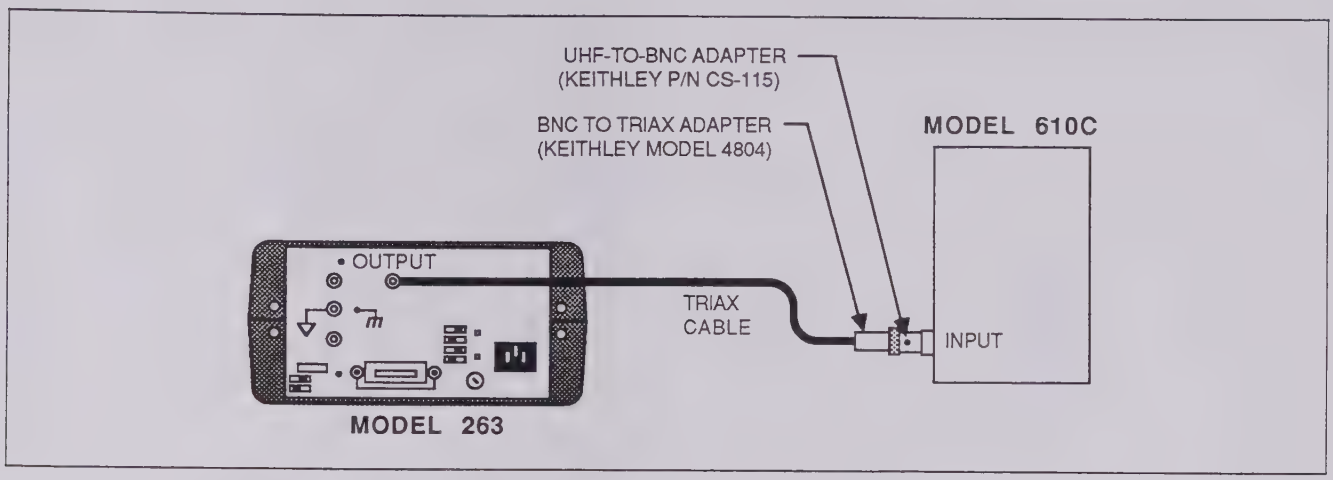


Figure 5-10. Model 610C Calibration

Accuracy Checks:

1. Voltage (step b) — Use the Model 263 to check all but the 1mV, 3mV, 30V and 100V ranges of the Model 610C. A Keithley Source Measure Unit (Model 236, 237 or 238) can be connected to EXT INPUT of the Model 263 in order to source 30V and 100V to the electrometer.
2. Current (Step c) — This procedure uses two different current sources (one custom built) to provide the required current levels. Instead, use the Model 263 to accurately source all required current levels.
3. Ohms (step d) — The procedures in this paragraph require precision resistors to check accuracy. Instead, use the Model 263 to source the appropriate resistance. When sourcing 100MΩ or more to the Model 610C, use guarding. For guarded ohms, enable guard on the Model 263, place the feedback switch of the Model 610C in the FAST position, and connect the instruments as shown in Figure 5-11.
4. Coulombs (step e) — This procedure sources 10V through a high-megohm resistor. A better technique to check charge accuracy is to source the appropriate charge level for each range using the charge source of the Model 263. Typical rise times using this technique is a couple of seconds and not the 10 seconds listed in Table 9 of the Model 610C manual.

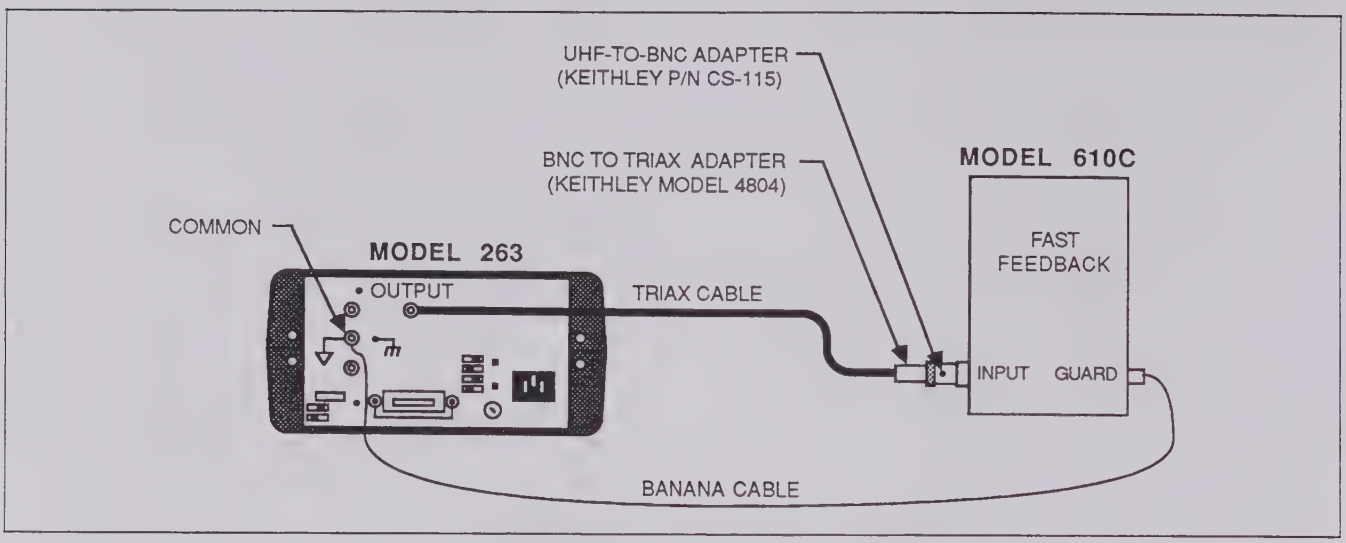


Figure 5-11. Model 610C Ohms Accuracy Checks (≥1GΩ)

5.4.6 Model 602 Electrometer Calibration

There are no adjustments involved in calibrating the ranges of the Model 602. Instead, calibration consists of checking range accuracy and replacing defective components (usually resistors out of specification).

Referring to the calibration procedure in the Model 602 Instruction Manual, use the Model 263 to check range accuracies of the electrometer. Connect the Model 263 to the Model 602 as shown in Figure 5-12.

1. Voltage Accuracy Check — Use the voltage source of the Model 263 to check all but the 1mV and 3mV ranges of the Model 602.
2. Current Accuracy Check — The procedure in this paragraph uses two different current sources to provide the required current levels. Instead, use the Model 263 to accurately source all required current levels.
3. Resistance Accuracy Checks — The procedures in this paragraph use precision resistors to check accuracy. Instead, use the Model 263 to source the appropriate resistance. When sourcing 100MΩ or more to the Model 602, it is recommended that guarding be used. For guarded ohms, enable guard on the Model 263, place the feedback switch of the Model 602 in the FAST position, and connect the instruments as shown in Figure 5-13.
4. Charge Accuracy Check — The procedure in this paragraph sources 10V through a high-megohm resistor. A better technique to check charge accuracy is to source the appropriate charge level for each range using the charge source of the Model 263. Typical rise times using this technique are a couple of seconds and not 10 seconds as listed in Table 4-3 of the Model 602 manual.
5. Unity-Gain Check — This procedure can be performed by using the Model 263 to source ±10.0000V.

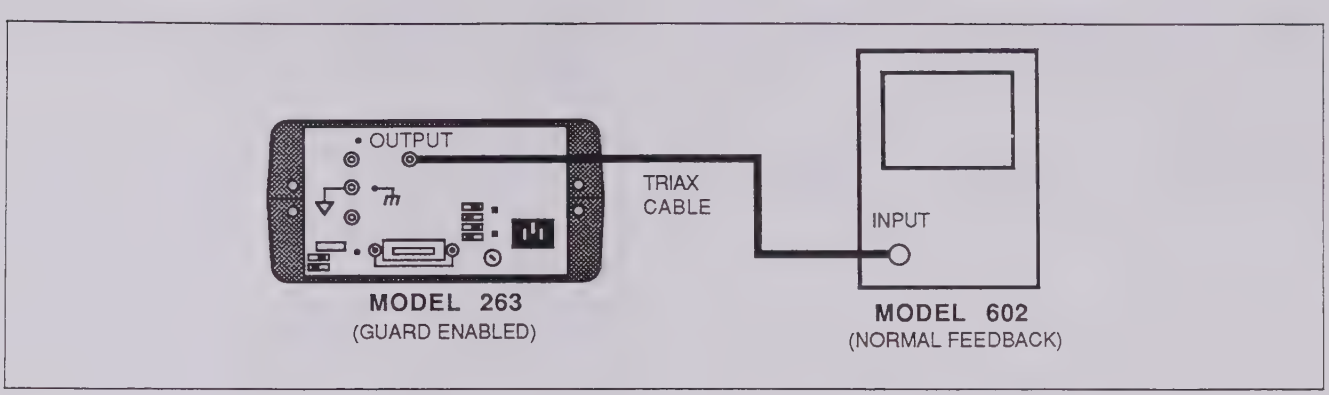


Figure 5-12. Model 602 Accuracy Checks

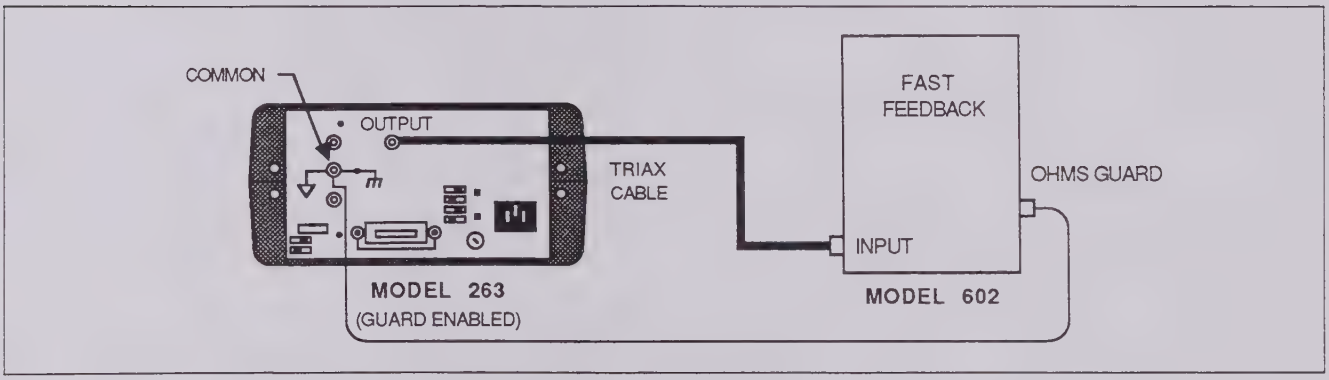


Figure 5-13. Model 602 Ohms Accuracy Checks (≥1GΩ)

5.4.7 Model 616 Electrometer Calibration

Connect the OUTPUT of the Model 263 to the INPUT of the Model 616 using the supplied triax cable. The Model 616 should be in NORMAL for all calibration adjustments. Referring to the calibration procedure found in the Model 616 Instruction Manual, use the Model 263 as follows:

1. Voltage Calibration (steps e 3-38)—These steps consist of applying voltages (5mV to 100V) to the electromter and adjusting the appropriate pots. The VOLTS source of the Model 263 will provide all but the 100V. To source 100V, connect a DC Calibrator (such as the Fluke Model 343A) to EXT INPUT of the Model 263. With the DC calibrator set to output 100V, pressing SHIFT VOLTS on the Model 263 will deliver the 100V to the electrometer.
2. Resistance Calibration (step f)—Use the Model 263 OHMS source to output 100kΩ to the electromter and make the appropriate adjustment.

5.5 SOURCING APPLICATIONS

The following paragraphs provide several applications using the Model 263 as a precision source.

5.5.1 Current Suppression

The Model 263 can be used to suppress steady background currents so that a picoammeter or electrometer can measure small variances in signal. For example, the Model

263 can be used to cancel phototube dark currents while the picoammeter measures small variances in the normal output of the phototube.

The basic circuit for current suppression is shown in Figure 5-14. The Keithley Model 617 Electrometer is used as the current measuring device. Other instruments with similar characteristics will serve equally well in this application.

The basic procedure for current suppression is as follows:

1. Using the Model 617 measure the unknown current.
2. Connect the Model 263 as shown in Figure 5-14.
3. Using the AMPS source of the Model 263, set the output polarity opposite to that of the unknown current, and source a current level that is as close as possible to the unknown current.
4. Vary the output of the Model 263 current source until a null on the Model 617 is achieved.
5. Gradually increase the sensitivity of the electrometer, nulling the current with the Model 263.
6. On the most sensitive range of the Model 617 where a null can be achieved, the small variances in the normal output can be monitored.

5.5.2 Galvanometric Measurements

In practice, using the Model 263 for galvanometric measurements is very similar to the current suppression procedure discussed in the previous paragraph. In this application the Model 263 bucks out an unknown current, while a current measuring instrument, such as the Model 617, serves as a null detector (see Figure 5-14).

Follow the same basic procedure for this measurement as described in the last paragraph. Once maximum nulling is achieved, the unknown current value can be determined by adding the Model 263 current source output value to any residual value shown on the measuring instrument (Model 617).

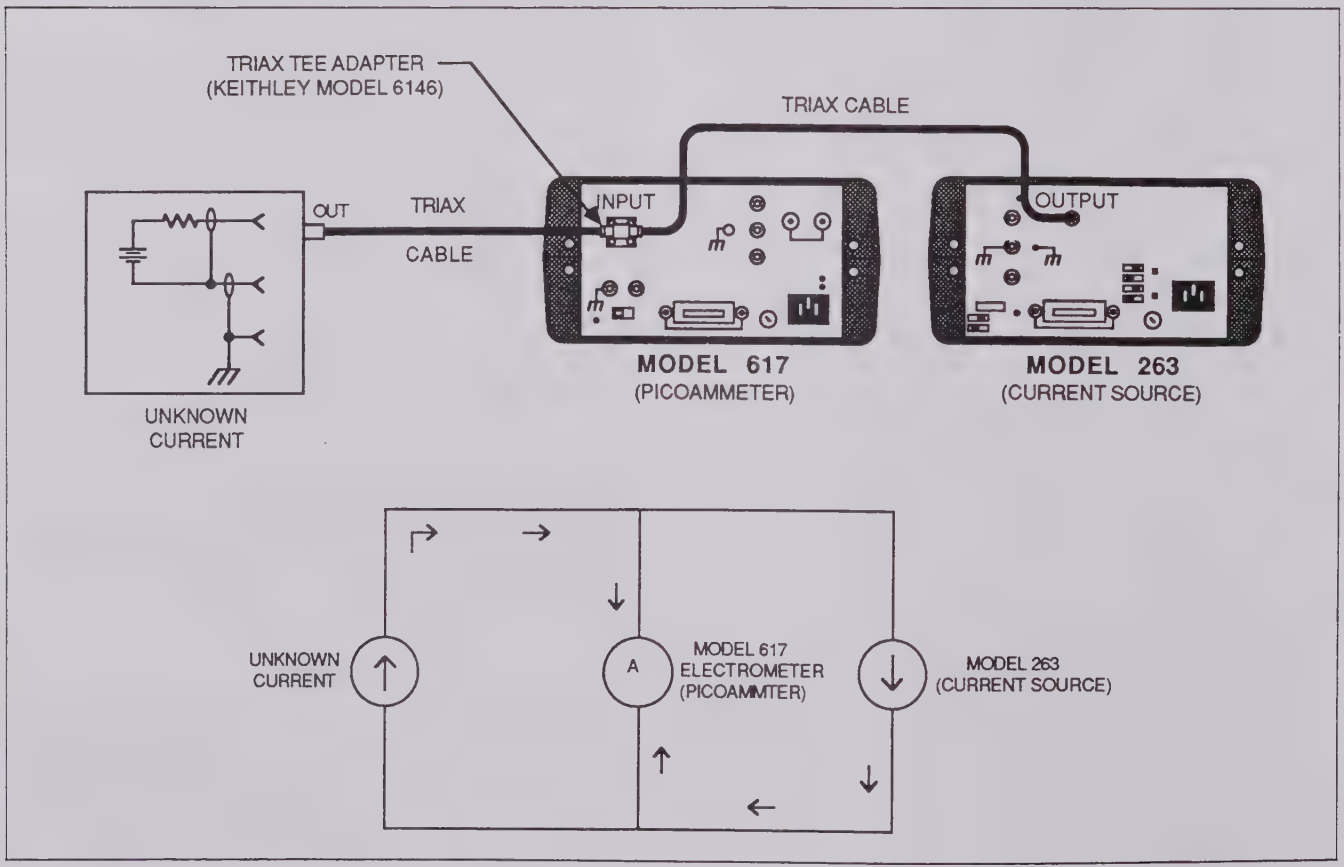


Figure 5-14. Nulling Circuit

5.5.3 Low Resistance "Lindeck" Measurements

The Model 263 AMPS source can be used in conjunction with the Model 181 Digital Nanovoltmeter to measure low resistance. The Model 263 is placed in parallel with the low unknown resistance (see Figure 5-15). In a circuit with a 0.01Ω resistance, a current source delivering 10mA (Model 263) will provide a resolution of 0.01% with the Model 181 on the 2mV range. With this method, the resistance may be found by dividing the voltage on the Model 181 by the current source value of the Model 263. With a 10mA current source and 0.01Ω resistance, a voltage of 100μV will result across the measured resistance.

5.5.4 Resistivity Measurements

Certain semiconductor materials, such as silicon, have high resistivities. The measurement of their resistivity can be a difficult measurement. To aid in their measurement, special probes of a hard metal, such as tungsten, are used. Because contact resistance is so high, a four point probe is used. The outer contacts supply a constant current, and the inner two contacts measure the voltage drop across a portion of the sample. With the geometry of the probe and wafer known, resistivity can then be calculated.

The current source must be stable and accurate. The Model 263 AMPS source is ideal for this application.

Refer to Figure 5-16 for an illustration of resistivity measurement. The voltmeter in the circuit requires a high input impedance to overcome lead resistance problems. The Keithley Model 617 has the high input impedance (greater than 200TΩ in parallel with 20pF) required to make the measurement accurately. For most wafers the resistivity is calculated as follows:

$$P = \frac{V}{ktI}$$

where

k = constant based on the geometry of the wafer and probe
t = sample thickness
V = measured voltage
I = current in the sample

5.5.5 Diode Characterization

With the Model 263 it is possible to obtain the necessary data to plot I-V (current-voltage) characteristics of a diode over several decades. Figure 5-17 shows the configuration to be used. The Model 617, with its high input resistance in the volts function, allows the measurement to be made accurately. Figure 5-18 shows several examples of diode curves which have been plotted using the configuration of Figure 5-17.

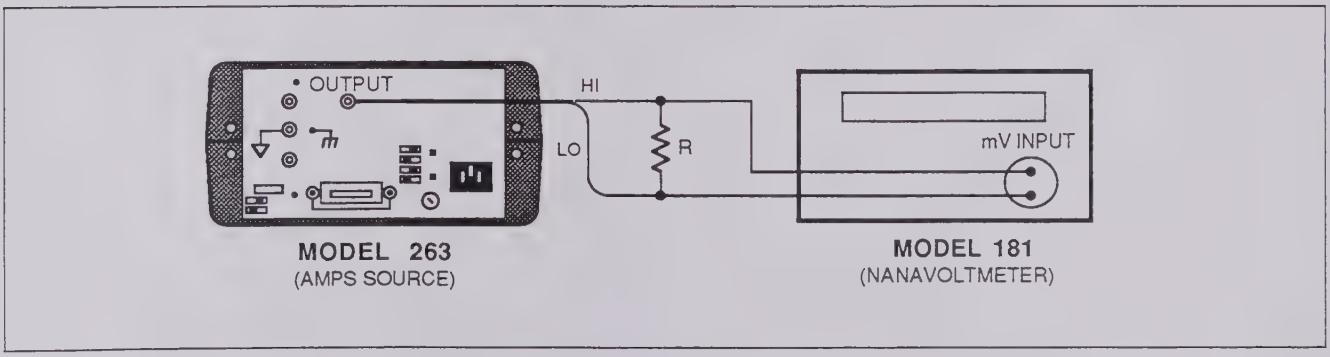


Figure 5-15. Low Resistance Measurement Connections

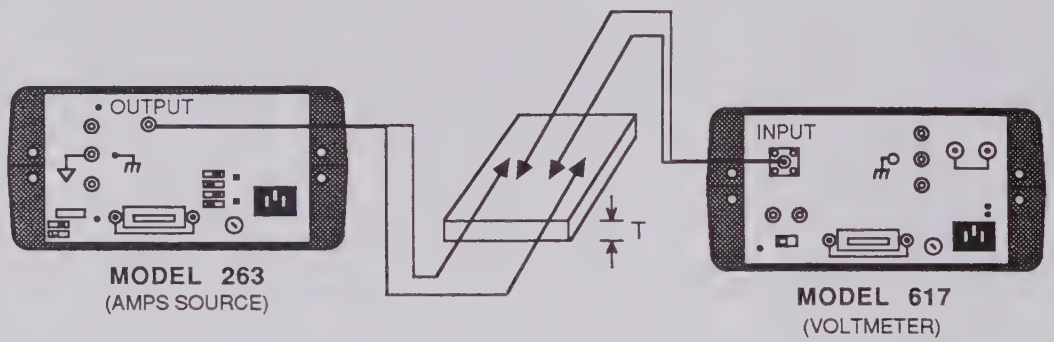


Figure 5-16. Resistivity Measurement Using the Model 263

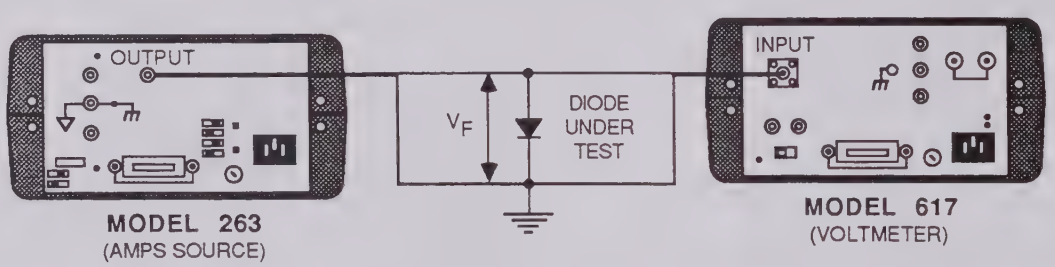


Figure 5-17. Diode Characterization

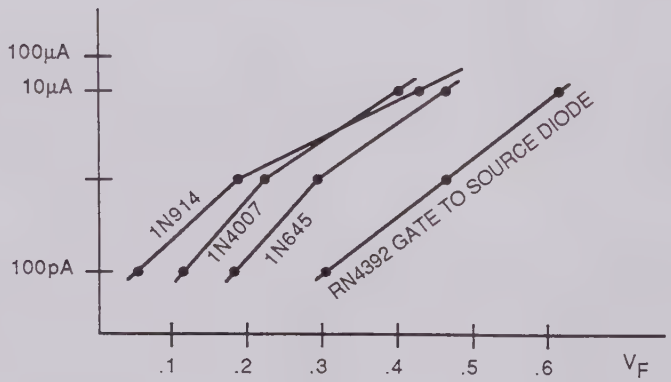


Figure 5-18. Diode Curves

SECTION 6
Performance Verification

6.1 INTRODUCTION

The procedures outlined in this section may be used to verify that the instrument is operating within the limits stated in the specifications at the front of this manual. Performance verification may be performed when the instrument is first received to ensure that no damage or misadjustment has ocurred during shipment. Verification may also be performed whenever there is a question of instrument accuracy, or following calibration, if desired.

NOTE

If the instrument is still under warranty (less than one year from the date of shipment), and its performance falls outside the specified range, contact your Keithley representative or the factory to determine the correct course of action.

6.2 ENVIRONMENTAL CONDITIONS

Accuracy checks should be made at 18° to 28°C and at less than 70% relative humidity.

6.3 INITIAL CONDITIONS

The Model 263 must be turned on and allowed to warm up for at least one hour before beginning the verification procedures. If the instrument has been subject to extremes of temperature (outside the ranges specified in paragraph 6.2), additional time should be allowed for internal temperatures to reach normal operating temperature. Typically, it takes one additional hour to stabilize a unit that is 10°C (18°F) outside the specified temperature range.

6.4 RECOMMENDED TEST EQUIPMENT

Table 6-1 lists all test equipment required for verification. Alternate equipment may be used as long as the substitute equipment has specifications at least as good as those listed in the table.

NOTE

The verification limits in this section do not include test equipment tolerance. The limits for all accuracy checks are derived from the 90 day accuracy specifications of the Model 263.

Table 6-1. Recommended Test Equipment

Description	Specifications	Manufactures; Model
5½ digit DMM	Volts; 50ppm	Keithley; 196
Picoammeter	20pA, 200pA, 1.6% 2nA-200nA; 0.25% 2μA-2mA; 0.15%	Keithley; 617
Resistance Calibrator	1kΩ; 108.5ppm 10kΩ; 68ppm 100kΩ; 59ppm 1MΩ; 61.5ppm 10MΩ; 126ppm 100MΩ; 620ppm	Fluke; 5450A
Female Triax to Male BNC Adapter	—	Keithley; 4804
Female BNC to Male Dual Banana Adapter	—	Pomona; 1269
Dual Banana to Banana Cable	—	Keithley; CA-18-1

6.5 PERFORMANCE VERIFICATION RECORD

Appendix G of this manual contains a performance verification record for organizations that need to keep track of verification results. The tables in this record are structured so that they can be used in place of the verification tables in this section. If using the verification record, make copies of the original form. The original form should not be written on or removed from this manual. If using the tables in this section, use a pencil for recording data. This allows the data to be errased so that the tables can be used again in the future.

6.6 VERIFICATION PROCEDURES

The following paragraphs contain procedures for verifying instrument accuracy. These procedures are intended for use only by qualified personnel using accurate and reliable test equipment. If the instrument is out of specification, refer to Section 8 for calibration procedures, unless the unit is still under warranty.

6.6.1 VOLTS Accuracy Verification

Using Table 6-2, perform the following steps to verify the accuracy of the Model 263 voltage source:

1. Zero correct the Model 196 as follows:
   A. Set the Model 196 to the 300mV range and short the input.
   B. If the display does not read 000.0000mV, press the ZERO button to zero out the offset.
   C. Remove the short from the input.

NOTE
If using a DMM that does not have zero correction capability, record the zero offset and subtract it from the subsequent voltage measurements to determine the actual output of the Model 263.

2. Connect the Model 263 to the Model 196 as shown in Figure 6-1.
3. Set the Model 263 to the 200mV range and the Model 196 to the 300mV range.
4. Program the Model 263 to output 00.000mV.
5. Verify that the reading on the Model 196 is 00.0000mV ±15μV.
6. Program the Model 263 to output 20.000mV (1/10 full scale) and verify that the reading on the Model 196 is 20.0000mV ±17.5μV.
7. Program the Model 263 to output −20.000mV (by pressing the ± button) and verify that the reading on the Model 196 is −20.000mV ±17.5μV.
8. Program the Model 263 to output 100.000mV (1/2 full scale) and verify that the reading is 100.000mV ±27.5μV.
9. Program the Model 263 to output −100.000mV and verify that the reading is −100.000mV ±27.5μV.
10. Program the Model 263 to output 190.000mV (near full scale) and then −190.000mV and verify that the readings are ±190.000mV ±38.7μV.
11. Using Table 6-2 as a guide, repeat the basic procedure in steps 3 through 10 to verify the 2V and 20V ranges of the Model 263.

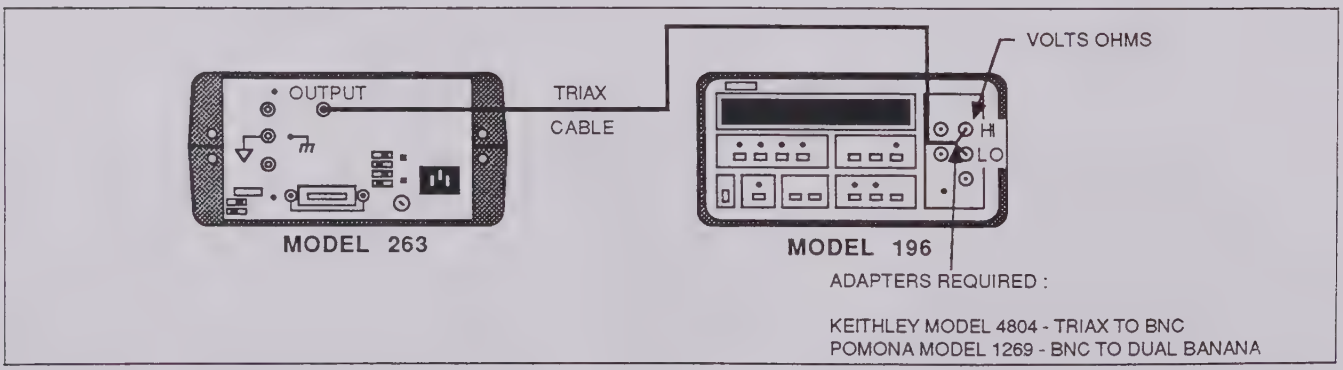


Figure 6-1. VOLTS Accuracy Checks

Table 6-2. VOLTS Accuracy Checks

263 Range	263 Programmed Output	196 Range	Allowable 196 Reading (18°C to 28°C)	196 Reading
200mV	00.000mV	300mV	−00.0150 to 00.0150	_____
200mV	±20.000mV	300mV	±19.9835 to ±20.0175	+ _____
				− _____
200mV	±100.000mV	300mV	±99.9725 to ±100.0275	+ _____
				− _____
200mV	±190.000mV	300mV	±189.9613 to ±190.0387	+ _____
				− _____
2 V	.00000 V	3 V	−.000050 to .000050	_____
2 V	±.20000 V	3 V	±.199925 to ±.200075	+ _____
				− _____
2 V	±1.00000 V	3 V	±.999825 to ±.000175	+ _____
				− _____
2 V	±1.90000 V	3 V	±1.899713 to ±1.900287	+ _____
				− _____
20 V	0.0000 V	30 V	−0.00050 to ±0.00050	_____
20 V	±2.0000 V	30 V	±1.99925 to ±2.00075	+ _____
				− _____
20 V	±10.0000 V	30 V	±9.99825 to ±10.00175	+ _____
				− _____
20 V	±19.0000 V	30 V	±18.99713 to ±19.00287	+ _____
				− _____

6.6.2 1kΩ Accuracy Check

Using Table 6-3, perform the following steps to verify accuracy of the 1kΩ range:

1. Place the Model 263 on the 1kΩ range and the Model 196 on the 3kΩ range.
2. Still using the test setup shown in Figure 6-1, disconnect the triax cable from the Model 263 and short the center conductor of the triax cable connector to its inner shield.
3. On the Model 196, press the ZERO button. This cancels the internal offset of the Model 196 and test lead resistance.

NOTE

If using a DMM that does not have zero correction capability, record the offset and subtract it from the reading in step 6 to determine the zero offset of the Model 263.

4. Reconnect the triax cable to the Model 263.
5. Program the Model 263 to output .00000kΩ.
6. The reading on the Model 196 is the zero offset of the Model 263. Verify that the offset is <1Ω.
7. On the Model 196, disable ZERO and again enable it. This zeroes out the offset of the Model 263 and Model 196, and test lead resistance.

Table 6-3. 1kΩ Accuracy Checks

263 Range	263 Programmed Output	196 Range	Allowable 196 Reading (18°C to 28°C)	196 Reading
1kΩ	.00000kΩ	3kΩ	<1Ω Zero offset	_____
1kΩ	1.00____kΩ	3kΩ	_____ to _____ (±0.04% × PO*) + PO*	_____

*PO = Programmed Output

NOTE
If using a DMM that does not have zero correction capability, record the reading and subtract it from the reading in step 11 to determine the actual output of the Model 263.

8. Program the Model 263 to output 1kohm (nominal) to the Model 196.
9. Record the programmed output reading displayed by the Model 263 in Table 6-3.
10. Calculate the allowable reading limits using the following equation and record them in Table 6-3.

Allowable reading = (±0.04% × PO) + PO

Where PO = Progammed Output

Example: Model 263 displays a resistance reading of 1.00025kΩ.

Allowable reading
= (±0.04% × 1.00025kΩ) + 1.00025kΩ
= ±0.00040kΩ+ 1.00025kΩ
= −0.999850kΩ to 1.000650kΩ

11. Verify that the reading on the Model 196 within the calculated reading limits.

6.6.3 AMPS Zero Offset Checks

Using Table 6-4, perform the following steps to check the zero offsets of the active (AMPS) current source ranges:

1. Set the Model 617 to the 2pA range and with an open input, allow the reading on the display to settle.
2. On the Model 617, press the SUPPRESS button to zero the display.

NOTE
If using a picoammeter that does not have zero correction capability, record the zero offset of the Model 617 and subtract it from the subsequent current measurements to determine the actual output of the Model 263.

3. Connect the Model 263 to the Model 617 as shown in Figure 6-2.
4. With the Model 263 on the 2pA range, program it to output .00000pA and verify that the reading on the Model 617 is .0000 ±100fA.
5. Using Table 6-4 as a guide, check zero offset of the other current ranges.

Table 6-4. AMPS Zero Offset Checks

263 Range	263 Programmed Output	617 Range	Allowable 617 Reading (18°C to 28°C)	617 Reading
2 pA	.00000pA	2pA	−.1000 to .1000	_____
20 pA	0.0000pA	2pA	−.1000 to .1000	_____
200 pA	00.000pA	2pA	−.1200 to .1200	_____
2 nA	.00000nA	20pA	−0.200 to 0.200	_____
20 nA	0.0000nA	200pA	−01.00 to 01.00	_____
200 nA	00.000nA	2nA	−.0100 to .0100	_____
2 μA	.00000 μA	20nA	−0.100 to 0.100	_____
20 μA	0.0000 μA	200nA	−01.00 to 01.00	_____
200 μA	00.000 μA	2 μA	−.0100 to .0100	_____
2mA	.00000mA	20 μA	−0.100 to 0.100	_____
20mA	0.0000mA	200 μA	−01.00 to 01.00	_____

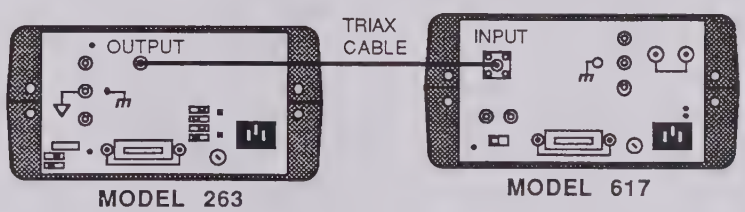


Figure 6-2. AMPS Zero Offset Checks

6.6.4 AMPS (200µA-2mA) Accuracy Checks

Using Table 6-5, perform the following steps to verify the accuracy of the 200µA through 2mA ranges of the active (AMPS) current source:

1. Connect the Model 263 to the Model 196 and Fluke Model 5450A as shown in Figure 6-3.
2. Set the Model 263 to the 20µA range, the Model 196 to the 3V range and the Model 5450A to output 100kΩ (nominal).
3. Program the Model 263 to output 0.0000µA (use ZERO button).
4. On the Model 196, press the ZERO button to zero its display.

NOTE

If using a DMM that does not have zero correction capability, record the zero offset and subtract it from the DMM reading in the next step.

5. Program the Model 263 to output 10.0000µA and record the Model 196 DMM voltage reading and the Model 5450A resistance reading in Table 6-5.
6. To determine the actual current output by the Model 263, divide the reading on the Model 196 (voltage drop across the resistor) by the reading on the Model 5450A (resistor value).
7. Verify that the calculated current is 10.0000µA ±3.5nA.
8. On the Model 263, press the ± button to output -10.0000µA.
9. Again, calculate the current (as in step 6) and verify that it is -10.0000µA ±3.5nA.
10. Program the Model 263 for 19.0000µA calculate the current and verify that it is within the limits listed in the table. Repeat for -19.0000µA.
11. Disable ZERO on the Model 196.
12. Connect the VOLTS OHMS terminals of the Model 196 to the SENSE terminals of the Model 5450A as shown in Figure 6-3.
13. Set the 263 to the 200µA range, the Model 196 to the 3V range and the Model 5450A to output 10kΩ.
14. Program the Model 263 to output 00.000µA.
15. On the Model 196, press the ZERO button to zero the display.

NOTE

If using a DMM that does not have zero correction capability, record the zero offset and subtract it from the DMM reading in the next step.

16. Program the Model 263 to output 190.000µA, and record the Model 196 DMM voltage reading and the Model 5450A resistance reading in the table.
17. Calculate the current and verify that it is within the allowable limits.
18. Disable ZERO on the Model 263.
19. Using Table 6-5 as a guide, repeat the basic procedure in steps 13 through 18 for the 2mA range.

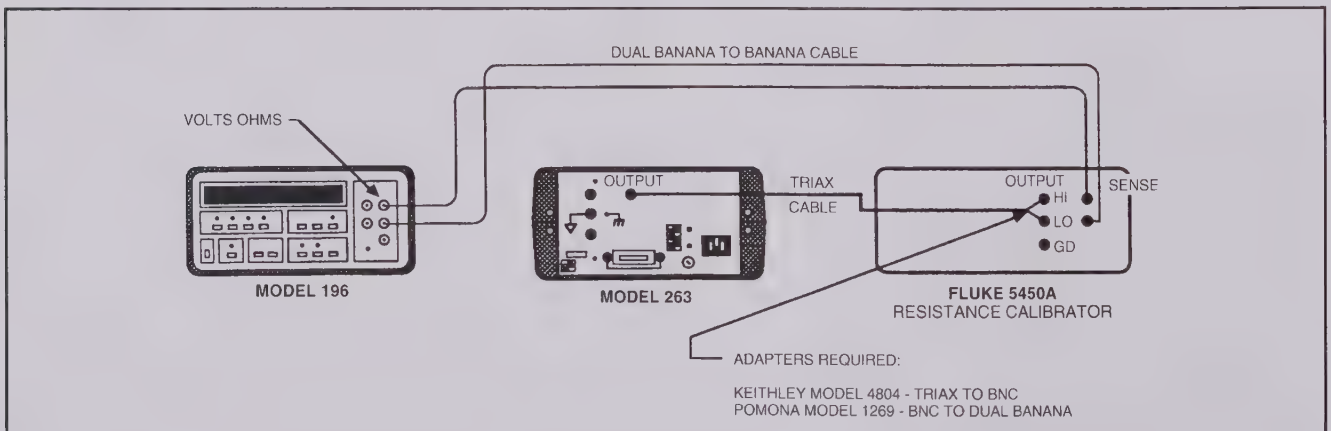


Figure 6-3. AMPS (200µA-2mA Ranges) Accuracy Checks

Table 6-5. AMPS (200µA-2mA) Accuracy Checks

263 Range	263 Programmed Output	196 Range	5450A Resistor (Nominal)	Setup (Figure)	Calculated Output Current 196 Reading ÷ 5450A Reading = Current	Allowable Calculated Current (18°C to 28°C)
20µA	10.0000µA	3V	100kΩ	6-4	_____ ÷ _____ = _____	9.9965µA to 10.0035µA
20µA	-10.0000µA	3V	100kΩ	6-4	_____ ÷ _____ = _____	-9.9965µA to -10.0035µA
20µA	19.0000µA	3V	100kΩ	6-4	_____ ÷ _____ = _____	18.9943µA to -19.0057µA
20µA	-19.0000µA	3V	100kΩ	6-4	_____ ÷ _____ = _____	-18.9943µA to -19.0057µA
200µA	190.000µA	3V	10kΩ	6-3	_____ ÷ _____ = _____	189.943µA to 190.057µA
2mA	1.90000mA	3V	1kΩ	6-3	_____ ÷ _____ = _____	1.89943mA to 1.90057mA

6.6.5 AMPS (20pA-2µA) Accuracy Checks

Using Table 6-6, perform the following steps to verify the accuracy of the 20pA through 2µA ranges of the active current source:

1. Connect the Model 263 to the Model 196 and Fluke Model 5450A as shown in Figure 6-4.
2. On the Model 196, enable the FILTER using a filter value of 60.
3. Set the Model 263 to the 20pA range, the Model 196 to the 300mV range, and the Model 5450A to output 100MΩ (nominal).
4. Program the Model 263 to output 19.0000pA and allow the reading on the Model 196 to settle (approximately one minute).
5. Record the settled positive voltage reading in Table 6-6.
6. On the Model 263, press the ± button to source negative current.
7. After allowing the reading to settle, record the negative voltage reading in the table.
8. Add the absolute values of the two readings and divide by two. Record this average voltage reading in Table 6-6 in the column titled "196 Avg".
9. Record the resistance reading of the Model 5450A in the table.
10. To determine the actual current output by the Model 263, divide the average voltage reading of the Model 196 by the resistance reading on the Model 5450A.
11. Verify that the calculated current is within the limits listed in the table.
12. Using Table 6-6 as a guide, repeat the basic procedure in steps 3 through 11 to verify the 200pA through 2µA ranges.

6.6.6 AMPS V/R Functional Checks

Using Table 6-7, perform the following steps to verify that the passive current (AMPS V/R) source is functional:

1. Connect the Model 263 to the Model 617 as shown in Figure 6-2.
2. Set the Model 263 and Model 617 to the 200pA range.
3. Program the Model 263 to output 00.000pA.
4. On the Model 617 press the SUPPRESS button to zero the display.
5. Program the Model 263 to output 190.000pA and verify that the reading on the Model 617 is 190.000pA ±3.05pA.
6. On the Model 617, disable SUPPRESS.
7. Using Table as a guide, repeat steps 2 through 5 for the 200µA range.

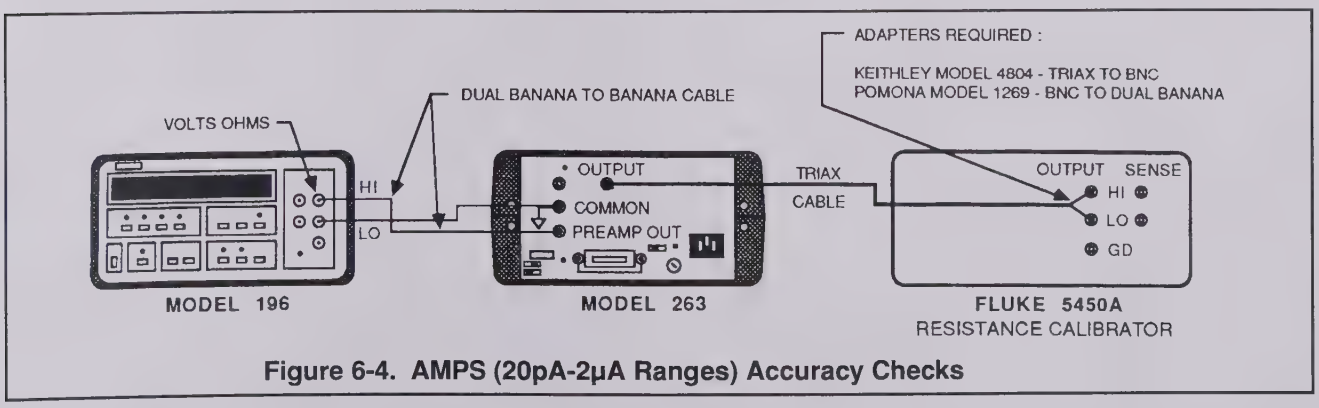


Figure 6-4. AMPS (20pA-2µA Ranges) Accuracy Checks

Table 6-6. AMPS (20pA-2µA) Accuracy Checks

263 Range	263 Programmed Output	196 Range	5450A Resistor (Nominal)	196 Reading	Calculated Output Current 196 Avg* ÷ 5450A Reading = Current	Allowable Calculated Current (18°C to 28°C)
20pA	19.0000pA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	18.9383pA to 19.0617pA
20pA	-19.0000pA	300mV	100MΩ	- _____		
200pA	190.000pA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	189.620pA to 190.380pA
200pA	-190.000pA	300mV	100MΩ	- _____		
2nA	1.90000nA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	1.89882nA to 1.90118nA
2nA	-1.90000nA	300mV	100MΩ	- _____		
20nA	19.0000nA	3V	100MΩ	+ _____	_____ ÷ _____ = _____	18.9882nA to 19.0118nA
20nA	-19.0000nA	3V	100MΩ	- _____		
200nA	190.000nA	3V	10MΩ	+ _____	_____ ÷ _____ = _____	189.934nA to 190.066nA
200nA	-190.000nA	3V	10MΩ	- _____		
2µA	1.90000µA	3V	1MΩ	+ _____	_____ ÷ _____ = _____	1.89953µA to 1.90047µA
2µA	-1.90000µA	3V	1MΩ	- _____		

*The average 196 reading is calculated by adding the absolute values of the positive and negative readings, and dividing by two.

Table 6-7. AMPS V/R Functional Checks

263 Range	263 Programmed Output	617 Range	Allowable 617 Reading* (18°C to 28°C)	617 Reading
200pA	190.000pA	200pA	186.95 to 193.05	_____
200µA	190.000µA	200µA	189.71 to 190.29	_____

*Reading limits determine by the accuracy specifications of the Model 617.

Table 6-6. AMPS (20pA-2μA) Accuracy Checks

263 Range	263 Programmed Output	196 Range	5450A Resistor (Nominal)	196 Reading	Calculated Output Current 196 Avg.*÷5450A Reading=Current	Allowable Calculated Current (18°C to 28°C)
20pA	19.0000pA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	18.9383pA to 19.0617pA
20pA	−19.0000pA	300mV	100MΩ	− _____		
200pA	190.000pA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	189.620pA to 190.380pA
200pA	−190.000pA	300mV	100MΩ	− _____		
2nA	1.90000nA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	1.89882nA to 1.90118nA
2nA	−1.90000nA	300mV	100MΩ	− _____		
20nA	19.0000nA	3 V	100MΩ	+ _____	_____ ÷ _____ = _____	18.9882nA to 19.0118nA
20nA	−19.0000nA	3 V	100MΩ	− _____		
200nA	190.000nA	3 V	10MΩ	+ _____	_____ ÷ _____ = _____	189.934nA to 190.066nA
200nA	−190.000nA	3 V	10MΩ	− _____		
2 μA	1.90000 μA	3 V	1MΩ	+ _____	_____ ÷ _____ = _____	1.89953 μA to 1.90047 μA
2 μA	−1.90000 μA	3 V	1MΩ	− _____		

*The average 196 reading is calculated by adding the absolute values of the positive and negative readings, and dividing by two.

Table 6-7. AMPS V/R Functional Checks

263 Range	263 Programmed Output	617 Range	Allowable 617 Reading* (18°C to 28°C)	617 Reading
200pA	190.000pA	200pA	186.95 to 193.05	_____
200 μA	190.000 μA	200 μA	189.71 to 190.29	_____

*Reading limits determine by the accuracy specifications of the Model 617.

SECTION 7
Principles of Operation

7.1 INTRODUCTION

This section contains an overall functional description of the Model 263 in block diagram form as well as details of the various sections of the instrument. Information concerning the voltage source, ohms source, current sources and charge sources is included.

Information is arranged to provide a description of each of the functional blocks within the instrument. Many of these descriptions include simplified schematics and block diagrams. Detailed schematic diagrams and component layout drawings for the various circuit boards are located at the end of Section 9.

7.2 OVERALL FUNCTIONAL DESCRIPTION

A simplified block diagram of the Model 263 is shown in Figure 7-1. The voltage source is comprised of a D/A converter and an inverting ranging amplifier. The D/A converter uses the pulse width modulation (PWM) method where the duty cycle of a square wave is filtered to obtain a DC value. The DC output of the PWM is then properly conditioned by the ranging amplifier and routed to the OUTPUT connector or to the current and charge circuitry.

OHMS sourcing is a simple matter of switch selecting the approprite range resistors and connecting them to the output.

Both current sources (AMPS and AMPS V/R) use the voltage and the OHMS range resistors to generate current. The AMPS V/R function sources current by placing a range resistor in series with the voltage source, while the AMPS function uses an electrometer amplifier to generate current.

The digital section is based upon the 146805E2 CMOS microprocessor. It performs the tasks of programming the A/D converter, controlling the configuration of the voltage source ranging amplifier, displaying data, and communicating over the IEEE-488 bus.

7.3 VOLTAGE SOURCE

Refer to the mother board schematic (263-106, sheet 2) for the following discussion on the voltage source. A block diagram of the voltage source is shown in Figure 7-2.

The heart of the voltage source is the 16-bit pulse width modulated (PWM) digital-to-analog converter (D/A). This type of D/A derives the DC output by varying the the duty cycle of a square wave and then filtering it. Figure 7-3 shows PWM waveforms that have a duty of cycle of 1:2 and 1:10. Filtering waveform A results in a DC value of ½ of the peak voltage. Filtering waveform B results in a DC value of 1/10 of the peak voltage.

The PWM output is generated by U9 and U10 (8-bit shift/store registers), U7 and U8 (magnitude comparators), U12 and U13 (binary counters), and U20 (NAND gates). Counters U12 and U13 are cascaded to provide one 16-bit counter. This counter is driven by 10MHz crystal Y1 to provide a fundamental PWM output frequency of 152.59Hz.

The comparator outputs of U7 and U8 are gated by U20 to obtain the PWM output. The PWM output is then sychronized with the clock at U5 (D-type flip-flop). The synchronized outputs of U5 (pins 8 and 9) are then buffered by U6 (MOSFET driver) that provides level shifting and the drive needed to switch Q2 and Q3 (N-channel MOSPOW FETs).

FETs Q2 and Q3 switch between an accurate, stable reference voltage (−10.6V) and signal common providing the accurate pulse width modulated signal. The output of Q2 and Q3 is filtered by the 3-pole active filter comprised of U3, R32, R33, R34, C28, C29 and C30 (see Figure 7-4). This filter provides 80dB of filtering at the fundamental frequency of the PWM signal. The filtered output is then applied to a low noise, low offset voltage inverting amplifier that has selectable gains of x2 (20V range), ÷5 (2V range) and ÷50 (200mV range).

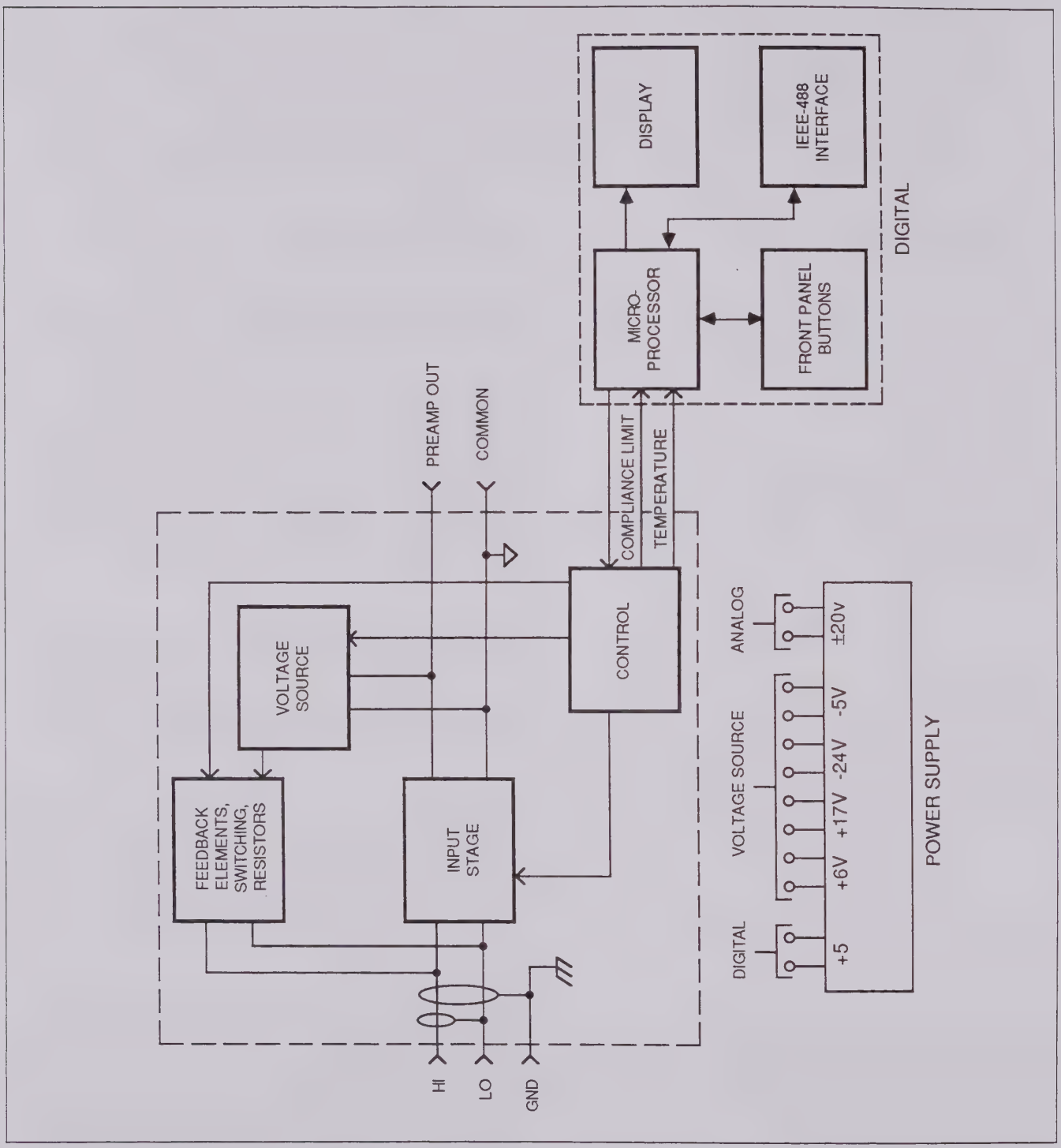


Figure 7-1. Model 263 Simplified Diagram

The ranging amplifier is an inverting amplifier comprised of two amplifiers; U38 and U39. Amplifier U38 is a low noise, low offset voltage, chopper stabilized amplifier that is responsible for the precise output of the composite amplifier. Amplifier U39 buffers the output of U38 providing the 20mA of drive needed for the 20mA range. Components C36, C37, R39 AND R41 serve to stabilize the composite amplifier circuit.

Range selection is accomplished by turning on the appropriate range FETs Q9 through Q13 (see Figure 7-5). A range FET is turned on by connecting its gate to ground. Table 7-1 defines which range FETs are on and and which feedback resistors are selected for each voltage range. Capacitors C31, C32 and C33 provide additional filtering for the inverted output. Resistor R40 isolates the output of amplifier U39 to prevent instability introduced by large capacitive loads. The simplified circuit of the composite ranging amplifier is shown in Figure 7-6.

The input to the inverting amplifier is always positive and thus, the output is always negative. In order to facilitate a ± output, the negative output of the amplifier is routed through an "H" bridge comprised power MOSFETs Q5 through Q8. For positive (+) polarity, Q5 and Q7 are on, and for negative (−) polarity, Q6 and Q8 are on.

Table 7-1. Voltage Source Ranges

Range	Amplifier Gain	Range FETs On	Feedback Resistor
200mV	÷50	Q9, Q10	R36‖R38
2 V	÷5	Q12, Q13	R36‖R37
20 V	×2	Q10	R36

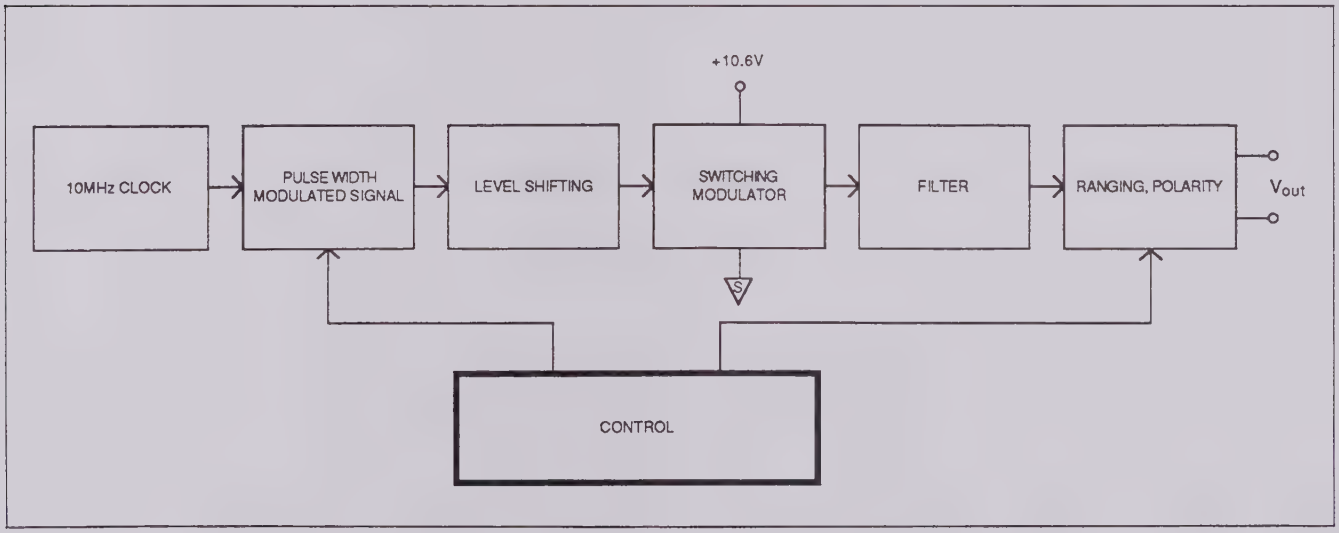


Figure 7-2. Voltage Source Block Diagram

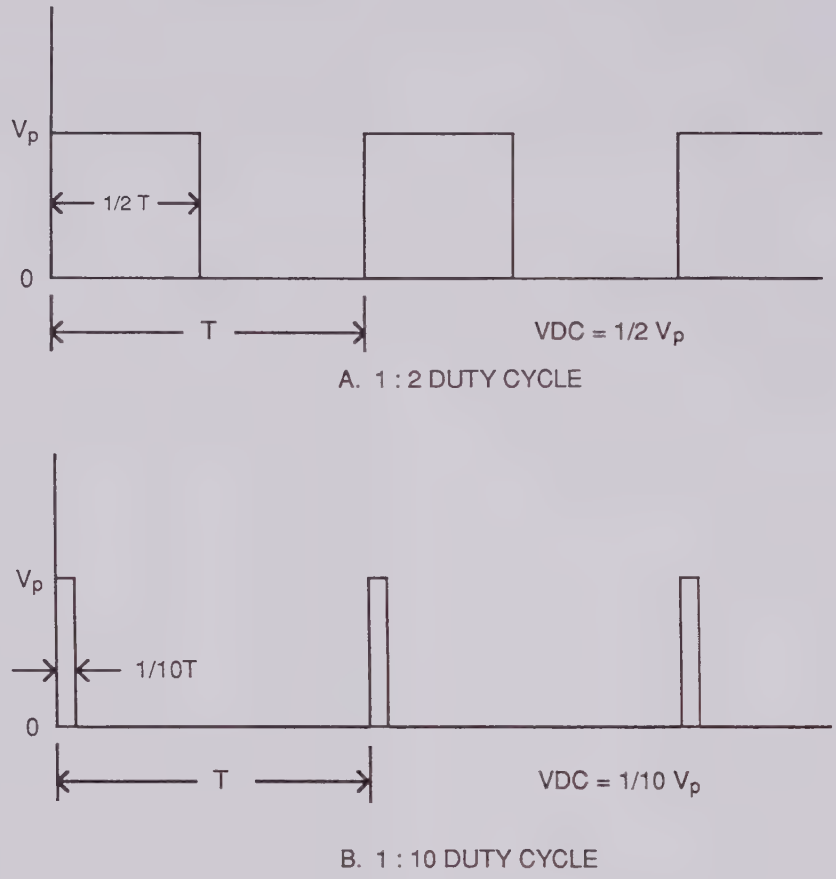


Figure 7-3. Pulse Width Modulation

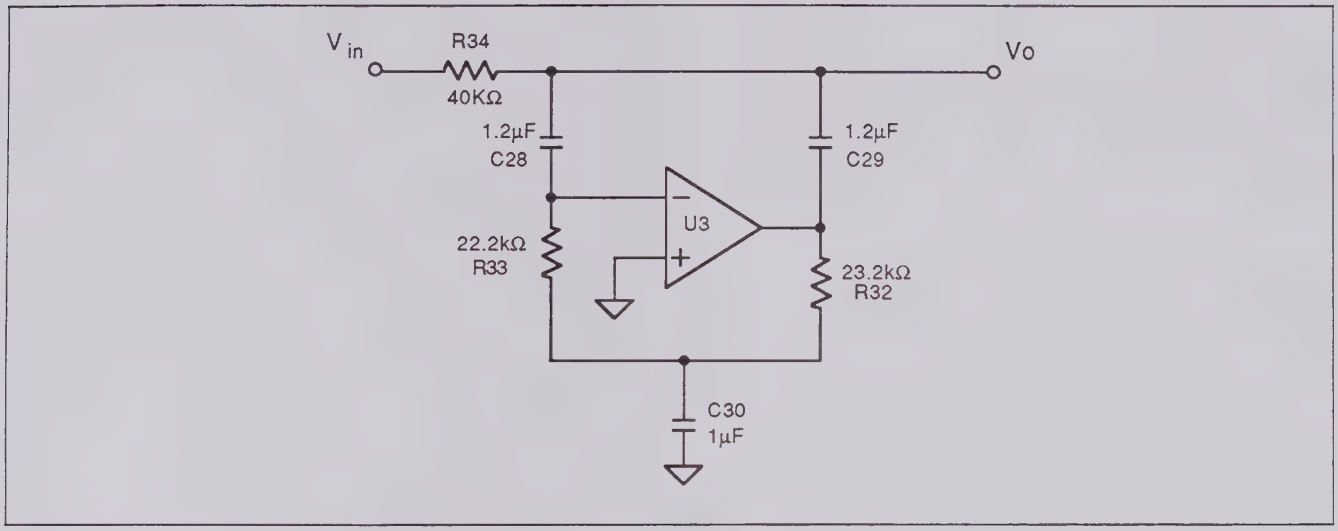


Figure 7-4. 3-Pole Filter

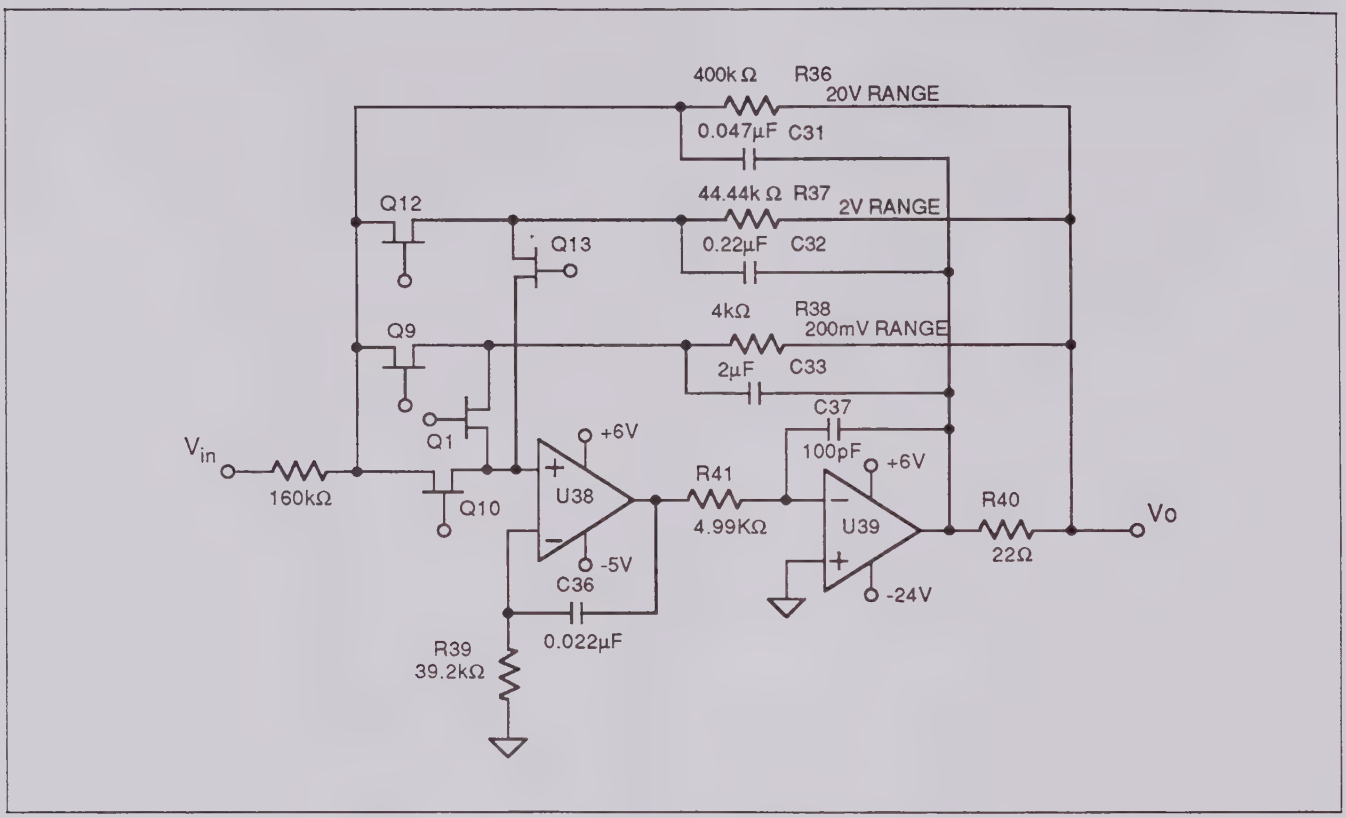


Figure 7-5. Voltage Source Ranging Amplifier

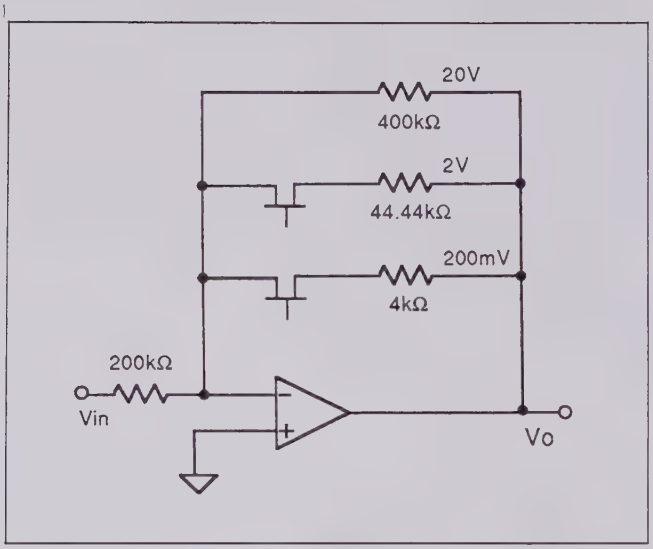


Figure 7-6. Simplified Voltage Source Ranging Amplifier

7.4 OHMS SOURCE

The circuit diagram for the ohms source is located on the analog board schematic (263 126). Resistance sourcing of the Model 263 is a simple matter of switch selecting the appropriate internal resistors and connecting them to the OUTPUT connector. Table 7-2 lists the selected resitors, and energized relays and FETs for each range.

In normal ohms, the selected resistance is connected to the center conductor (HI) and the inner shield (LOW) of the triax OUTPUT connector. With GUARD enabled, the resistance is removed from the inner shield and routed to the COMMON terminal. This allows a driven guard to be connected to the inner shield of the triax connector.

7.5 CURRENT SOURCES

In both AMPS V/R and AMPS, the voltage source and OHMS range resistors are used to generate current. Refer to the analog board schematic (263-126) for the discussion on the active (AMPS) current source.

Table 7-2. OHMS Source Ranges

263 Range	Selected Resistors	Relays Energized	FETs Energized
1 kΩ	R30‖R25‖R26	K12, K13, K11, K8	
10 kΩ	R30‖R23‖R32	K3, K13, K11, K8	
100 kΩ	R30‖R24‖R32	K4, K13, K11, K8	
1MΩ	R30‖R32	K13, K11, K8	
10MΩ	R30‖R27‖(R28 + R29)	K13, K11, K6. K7	Q7, Q8
100MΩ	R30‖R31‖R33	K13, K11, K9, K10	
1GΩ	R30‖R27	K13, K11, K6	Q7
10GΩ	R30‖R33	K13, K11, K9	
100GΩ	R30	K13, K11	

7.5.1 Passive (AMPS V/R) Current Source

For this current source, the voltage source is simply connected in series with the appropriate range resistor as shown in Figure 7-7. The range resistors used are the same ones used by the OHMS source. The range resistance voltage source range used for each current range is listed in Table 7-3.

In this series circuit configuration, the actual current is dependent on the voltage burden seen at the output and is calculated as follows:

$$I_{OUT} = \frac{\text{V-Source} - V_{BURDEN}}{R_{RANGE}}$$

From this equation, it can be seen that the smaller the voltage burden, the closer the output current will be to the programmed current. For this reason the passive (AMPS V/R) current source should only be used with devices (such as a feedback picoammeter) that have a small ($<100\mu V$) voltage burden.

To output a programmed current, the microprocessor sets the voltage source accordingly to compensate for inaccuracies of the range resistance. For example, if the programmed current is 10.0000pA and the range resistance is actually 101GΩ, the voltage source will be set to 1.01V (10pA × 101GΩ = 1.01V).

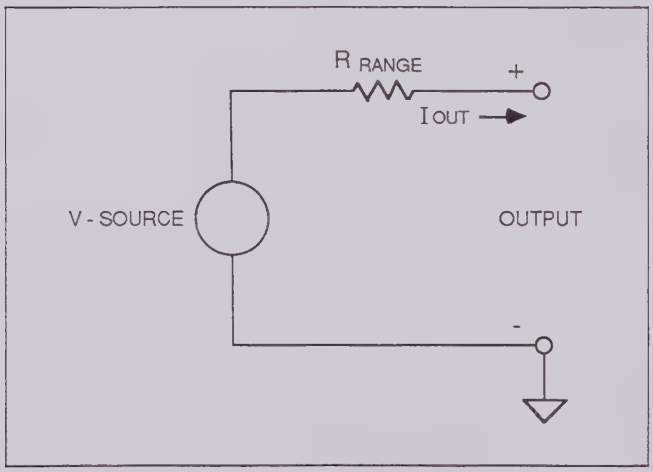


Figure 7-7. Passive (AMPS V/R Current Source)

7.5.2 Active (AMPS) Current Source

For this current source the voltage source, range resistors and an electrometer amplifier are configured as shown in Figure 7-8. A simplified circuit of the active current source is shown in Figure 7-9. This sourcing method is independent of burden voltage. In this configuration, the voltage source floats on the output of the electrometer amplifier. As with the passive (AMPS V/R) current source, the voltage source is set according to the actual value of the range resistance. The active (AMPS) current source uses the same range resistors and voltage source ranges as the passive (AMPS V/R) current source (see Table 7-3).

Table 7-3. Current Range Resistances

Current Range	R_{RANGE} (Nominal)	V-Source Range
2 pA	100GΩ	200mV
20 pA	100GΩ	2 V
200 pA	10GΩ	2 V
2 nA	1GΩ	2 V
20 nA	100MΩ	2 V
200 nA	10MΩ	2 V
2 μA	1MΩ	2 V
20 μA	100 kΩ	2 V
200 μA	10 kΩ	2 V
2mA	10 kΩ	20 V
20mA	1 kΩ	20 V

The electrometer amplifier is comprised of U9 and U13. Operational amplifier U9 is configured as a buffer to provide the necessary drive current, and U13 provides the high input impedance and low bias current. The power supply (±V) for the electrometer amplifier is bootstrapped to the output voltage of this stage. Thus, the supply voltage to U9 and U13 will always be within 7.2V of the output (U9, pin 6). This keeps the common mode voltage at U13s input to zero volts, eliminating bias current changes as the burden voltage varies.

The bootstrap is comprised of constant current diodes Q5 and Q6 that bias zeners VR1 and VR2. The voltage developed accross VR1 and VR2 is buffered by Q3 and Q4. Transistors Q3 and Q4 supply the necessary current to U9 and U10.

Compliance voltage limit is detected by U8 (dual voltage comparator), VR4, VR5, R14 and R42, and typically occurs

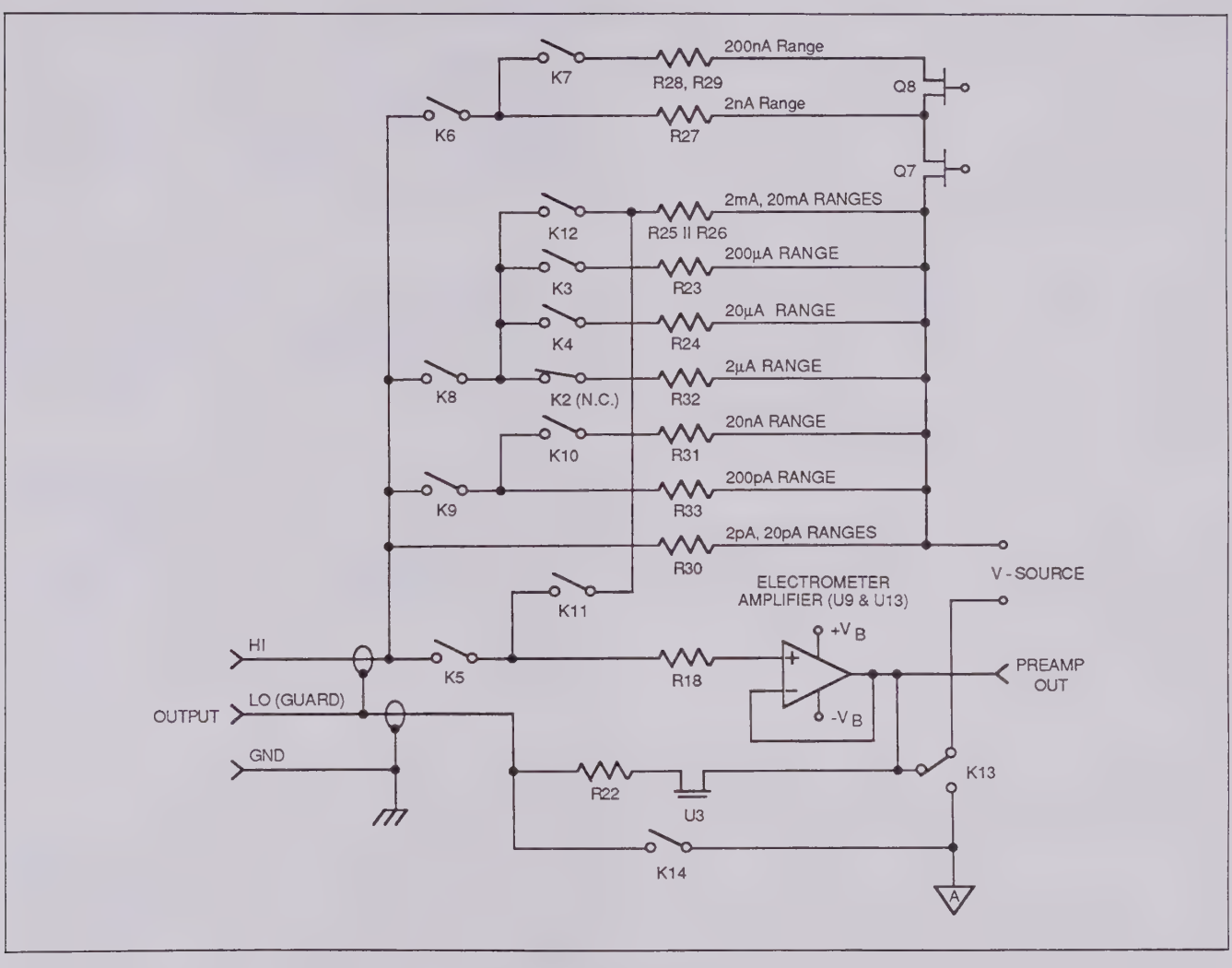


Figure 7-8. Active (AMPS) Current Source Circuitry

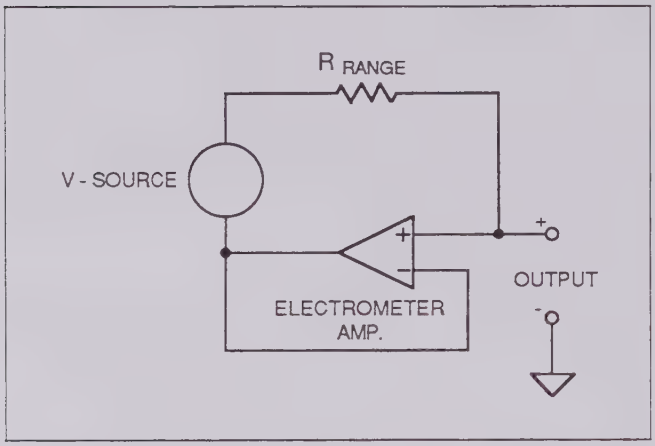


Figure 7-9. Active (AMPS) Current Source

at 15V (flashing OPERATE light). Once compliance is reached, the output will become inaccurate. Comparator U8 detects compliance voltage limit when the output of U9 gets to within 6.3V of the supply voltages of U8.

7.6 CHARGE SOURCES

In general, the Model 263 sources charge by applying the appropriate current for one second. The charge, current and time relationship is defined by the following equation:

$$Q = i \times t$$

where:

Q = charge in coulombs.
i = current in amps.
t = time in seconds.

Passive coulombs (COUL V/R) uses the passive current source (AMPS V/R), and active coulombs (COUL) uses the active current source (AMPS). Switching for coulombs is performed by Q5 through Q8 (see mother board schematic; 263-106, sheet 2). In standby, Q5 and Q6 are on. For negative (−) charge souring, Q5 turns off and Q8 turns on when OPERATE is pressed. For positive (+) charge sourcing, Q6 turns off and Q7 turns on when OPERATE is pressed. After one second of charge sourcing, the Model 263 goes back into standby.

7.7 TEMPERATURE COMPENSATION

Refer to the analog schematic (263-126) for the following discussion. Correction for temperature variation is performed by the microprocessor for the 1Gohm through 100GΩ resistance ranges, 2pA through 1nA current (AMPS and AMPS V/R) ranges, and the 20pC through 2nC charge (COUL and COUL V/R) ranges.

When the instrument is calibrated, the 1GΩ, 10GΩ and 100GΩ resistors are calibrated at two temperatures in order to determine their temperature coefficients (TCs) over the 0°C to 50°C operating temperature span. The actual temperature measurement is performed by U11, which is a temperature to current converter that produces a 1μA change for each 1°C change in temperature. The output current of U11 is transformed into a voltage by R39, U12, R37, R38 and VR3. The 0V to 1V output of U12 is then processed by U31 a voltage to frequency converter. The frequency output is then tranmitted to the microprocessor over the opto coupler U43. Once the present temperature is known, the microprocessor calculates the new resistance using the TC determined at calibration and diplays it. When sourcing current or charge, the voltage source is adjusted to compensate for the change in resistance in order to maintain a constant output.

7.8 DIGITAL CIRCUITRY

Model 263 operation is controlled by the internal microcomputer and associated software. The following paragraphs briefly describe the various aspects of the digital circuitry. Descriptions are keyed to the digital circuitry schematic (drawing number 263-106, page 1) located at the end of Section 9.

7.8.1 Microcomputer

Microcomputer operation centers around the 8 bit 146805 CMOS microprocessor, U14. The device utilizes an 8 bit data bus and incorporates a multiplexed data/address bus for the lower eight bits of the 12 bit address bus. The 146805 has 112 bytes of on-chip memory, two 8 bit I/O parts, and is capable of directly addressing 8K bytes of memory. The microprocessor unit has direct control over the display, front panel switches, digital-to-analog, the sources, the IEEE-488 bus, as well as the Preamp Out and Ext Input.

Microprocessor timing is performed by Y2, a 3.2768 MHz crystal. The signal is internally divided by five to obtain a bus operating frequency of 655.36kHz. This signal is present at the AS terminal of the processor, and is used as a control signal to strobe the lower ordered eight bits of the address into the address latch, U16. A 655.36kHz signal is also present at the DS terminal to act as a system clock.

7.8.2 Memory Elements

Software for the Model 263 is stored in U47, a 16K X 8 PROM. Temporary storage is afforded by U46, a 2K X 8 RAM IC. The microprocessor unit uses the RAM for temporary storage.

Calibration constants, the display mode, and the IEEE-488 primary address are stored in the NVRAM, U15 and U41. During the power-up cycle, NVRAM data is transferred to normal RAM to allow easier access during operation. While data transmission to the ROM and RAM are done in parallel, NVRAM data transmission is performed serially.

7.8.3 Device Selection

The 146805 processor can directly address only 8K bytes of memory. The Model 263 requires greater addressing capability, as 16K of ROM, 2K of RAM, and other memory space requirements are present in the system. To get around this problem, device selection circuitry is incorporated with the micorcomputer.

Device selection is performed by elements of U18, U21, and U40. Microprocessor unit lines used, part of the selection process, include the A10-A12 address lines, the PB6 line, the PB7 line, and the DS line. Signals generated by this circuitry include a line which controls the ROM chip select, a signal line that controls the RAM chip select, and circuitry which enables the display control and IEEE-488 bus circuits. Additional device selection signals include the memory paging signals. Two signals divide the 16K ROM area into 4K pages, while a third signal divides the 2K RAM area into two 1K pages.

Because of the paging scheme employed, several devices can occupy a given address within the microprocessor's addressing space.

7.8.4 IEEE-488 Bus

The Model 263 has a standard IEEE-488 interface that allows the instrument to be programmed from a system controller. Commands can be sent over the bus to the instrument, and data can be requested from the instrument as well.

The IEEE-488 interface is made up of U26, U28 and U29. U29 is a GPIA (General Purpose Interface Adapter), while U26 and U28 are interface bus drivers.

The GPIA simplifies microprocessor unit interfacing to the IEEE-488 bus because many control sequences take place automatically. For example, when the microprocessor unit writes to the GPIA data output register, the handshake sequence is performed automatically. Without the GPIA chip, complex microprocessor unit routines would otherwise be required.

On the microprocessor unit side of the GPIA, data transmission is handled much like any other data bus transaction. Microprocessor unit data access is performed through the D0-D7 lines, while the RS0-RS2 lines (which are connected to the three least significant address lines) serve to select among the 14 internal registers (seven read, seven write) of the integrated circuit. Chip selection is performed by the CE line.

The output of the GPIA IC is in standard IEEE-488 format; the eight data lines (DIO1 - DIO8), the three handshake lines (DAV, NRFD, NDAC), and the five management lines (ATN, REN, IFC, SRQ, and EOI) are all active low with approximately zero volts representing a logic one. The two IEEE-488 bus drivers, U26 and U28, are necessary to bring the drive capability of the interface up to the requirements of the IEEE-488 standard, which included provisions for up to 15 devices to be connected to the bus at one time. The outputs of the bus drivers are connected to J2, which is a standard IEEE-488 connector.

7.9 DISPLAY CIRCUITRY

Display circuitry includes those elements necessary to control the seven and 14 segment readouts, the front panel annunciator LEDs, and to read the front panel switches. The display circuitry schematic may be found on drawing number 263-116, located at the end of Section 9.

The display circuitry consists of the LED readouts (DS1 - DS7), the LED annunciators (DS8 - DS22), the segment drivers (U1 and U2) and the digit select circuitry (U4, U5 and U6). DS2 - DS6 are standard 7-segment units, while DS7 is a dual 14-segment display.

The display is updated at 1.56msec intervals. Timing for this process is performed by a 640Hz clock which controls the segment latches, U22 and U23, located on the mother board. Each time an interrupt is generated, the microprocessor unit writes segment data for two digits to the segment latches. The two latches outputs are then enabled in sequence by the 640Hz clock. When a latch output is enabled, segments in the selected digit are turned on.

When a latch output is enabled, segments in the selected digit are turned on. Digit selection is performed by data from the PA3, PA4, and PA5 outputs of the microprocessor unit to control U4. A single U4 output, corresponding to the selected digit, will go low when the correct data appears on its inputs. For example, if 010_2 appears on the inputs of U4, DS1 will be turned on.

Selection of the display annunciators is performed in a similar manner. The data stored in the corresponding segment latches will then turn on the appropriate annunciator LEDs.

Front panel switches are read in a somewhat similar manner by using a row-column matrix along with U3. To select a particular row, data is transmitted out the microprocessor unit PA3, PA4 and PA5 lines to U3. This action selects one of the rows by placing the corresponding output of U3 high. Matrix columns are then read by reading data in through PA0, PA1, and PA2, of the microprocessor unit. If a particular switch contact is closed, the data bit will be high; if the switch is open, the data bit will be low.

7.10 MAIN POWER SUPPLY

The diagram for the main power power supply is located on drawing 263-106, sheet 2. AC power is applied to J1, which is the power connector located on the rear panel of the instrument. S1 is the POWER switch located on the front panel, while S2 is the line voltage selection switch. When S2 is in the 115V position, the primary windings are connected in parallel; when S2 in in the 230V position, the T1 windings are placed in series.

T1 has three secondary windings which are used to supply the ±V, +17V, −24V, and +5V supplies. The +V supply is then used to supply the +6V supply while the −24V supply is used to supply the −5V supply. The +17V, −24V, +6V and the −5V supplies are used to supply the voltage source. The +17V supply is also used to generate the +10.6V reference for the PWM circuitry. The +5V supply is used for the dititat circuitry and the ±V supplies are used for the analog circuitry.

The ±V supplies (~ ±20V) consist of a full-wave rectifier (CR2) and filter capacitors (C38 and C39). Rectification for the +17V supply is provided by CR5 and CR8. Filtering is provided by C44, and regulation is provided by U49. Rectification of the −24V supply is provided by CR4 and CR7. Filtering is provided by C45, and regulation is provided by U42. Rectification of the +5V supply is done by elements of CR1, while filtering is performed by C1. The supply voltage is regulated by U33.

The +6V supply is derived by applying the unregulated +V supply to U5. Resistors R4 and R5 adjust the regulator to output the proper voltage. The −5V supply is derived by simply applying the −24V supply to a −5V regulator (U50).

The +10.6V reference is supplied by the +17V supply. U2 provides the reference, while U4, Q15, R3, R9 and R10 provide a constant current to minimize zener voltage variation.

SECTION 8
Maintenance

8.1 INTRODUCTION

This section contains information necessary to maintain, calibrate, and troubleshoot the Model 263. Fuse replacement and line voltage selection procedures are also included.

WARNING
The procedures included in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps in this section may expose you to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

8.2 LINE VOLTAGE SELECTION

The Model 263 may be operated from either 105-125V or 210-250V 50 or 60Hz power sources. A special transformer may be installed for 90-110V and 180-220V ranges. The appropriate box on the rear panel (see Figure 8-1) is marked to indicate which transformer is installed. The upper box indicates that the low voltage transformer is installed, while the lower box indicates the higher voltage transformer is installed. The position of the switch indicates the selected line voltage. To change the line voltage, proceed as follows.

WARNING
Disconnect the Model 263 from the power line and all other sources before removing the top cover.

1. Locate the line voltage switch on the rear panel. Referring to Figure 8-1, place the switch in the correct position; to the right for low line voltage (90 to 125V) or to the left for high line voltage (180 to 250V).
2. Install a fuse consistent with the operating voltage, as described in paragraph 8.3.

CAUTION
The correct fuse type must be used to maintain proper instrument protection.

3. Mark the selected line voltage on the rear panel for future reference (to avoid confusion, erase any old marks).

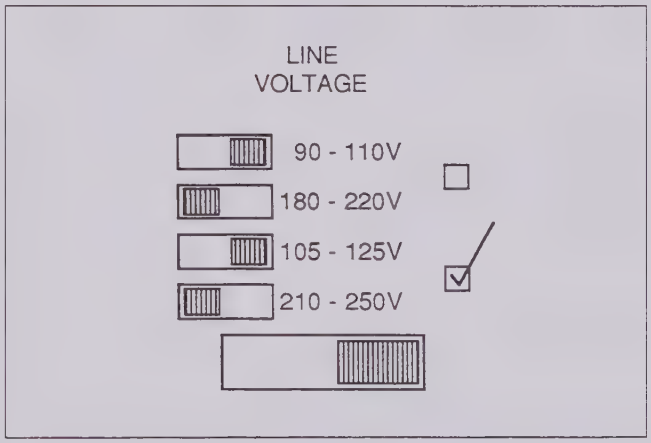


Figure 8-1. Line Voltage Switch (105-125V Range Selected)

8.3 FUSE REPLACEMENT

A rear panel fuse protects the power line input of the instrument. Use the following procedure to replace the line fuse.

WARNING
Disconnect the instrument from the power line and other equipment before replacing the fuse.

1. With the power off, place the end of a flat-blade screwdriver into the slot in the rear panel LINE FUSE holder. Push in gently and rotate the fuse carrier one-quarter turn counterclockwise. Release pressure on the holder and its internal spring will push the fuse and carrier out of the holder.
2. Remove the fuse and replace it with the type recommended in Table 8-1.

CAUTION
Do not use a fuse with a higher current rating than specified, or instrument damage may occur. If the instrument repeatedly blows fuses, locate and correct the cause of the trouble before replacing the fuse.

3. Install the new fuse and the fuse carrier into the holder by reversing the above procedure.

Table 8-1. Line Fuse Selection

Line Voltage	Fuse Type	Keithley Part No.
90-125V	¼A, 250V, 3AG, Slo Blo	FU-17
180-250V	1/8A, 250V, 3AG, Slo Blo	FU-20

8.4 CALIBRATION

Except for one manual adjustment, the entire calibration procedure is digital in nature and can be done from the front panel or over the IEEE-488 bus.

Calibration should be performed every 90 days or 12 months (depending on accuracy requirements), or if the performance verification procedures in Section 6 show that the instrument is out of specification. If any of the calibration procedures cannot be performed properly, refer to the troubleshooting information in this section.

8.4.1 Calibration Overview

The Model 263 is calibrated twice. The first calibration is performed when the instrument is first turned on and is referred to as the "cold" calibration. The second calibration is performed after the instrument is thoroughly warmed up and is referred to as the "hot" calibration. By calibrating the Model 263 at these two temperature points, the actual temperature coefficients (TC) of the 1GΩ, 10GΩ and 100GΩ resistors are determined and stored for use on these resistance ranges and the lower current ranges.

"Cold" calibration consists of calibrating the volts and ohms ranges right after the instrument is turned on. After allowing the instrument to warm up for a minimum of three additional hours, "hot" calibration is performed. "Hot" calibration consists of again calibrating the volts and ohms ranges.

Calibrating the >1MΩ ranges can be done by two methods; direct resistor measurement or the internal calibration "ladder" technique. The direct resistor measurement method requires equipment that can accurately measure the resistors. The measured values are used as the calibration values. The accuracy requirements for this method are contained in paragraph 8.4.2. The "ladder" technique compares each >1MΩ resistor with one of the previously measured resistors to determine its value. The "ladder" method is the preferred method here because a single precision DMM (Model 196) can be used to calibrate the Model 263.

8.4.2 Recommended Calibration Equipment

Table 8-2 lists recommended calibration equipment. An alternate DMM may be used as long as it meets the accuracy specifications in the table.

If using the direct measurement method to calibrate the >1MΩ ranges, use equipment with the following specifications. Note that these accuracy specifications represent the accuracy required of the entire measurement set-up.

10MΩ Range - 0.02%
100MΩ Range - 0.045%
1GΩ Range - 0.05%
10GΩ Range - 0.19%
100GΩ Range - 0.19%

8.4.3 Environmental Conditions

Calibration must be performed under laboratory conditions having an ambient temperature of 23°C ± 1°C and a relative humidity of less than 70%.

Table 8-2. Recommended Calibration Equipment

Description	Specifications	Manufacturer and Model
5½ Digit DMM	Volts; 50ppm 1kΩ, 10kΩ; 75ppm 100kΩ, 1MΩ; 100ppm	Keithley; 196 (24 Hr. Specs)
Female triax to male BNC adapter	—	Keithley; 4804
Female BNC to male Double banana adapter	—	Pomona; 1269
Dual banana to banana cable	—	Keithley; CA-18-1

8.4.4 Cool-down Period

The instrument must be off and in the calibration lab environment (see previous paragraph) for at least four hours. This allows the instrument to reach the temperature of the calibration lab so that "cold" calibration can be performed.

8.4.5 Calibration Switch

A switch, located on the rear panel (see Figure 8-2), allows the technician to disable or enable front panel and IEEE-488 bus calibration. When the switch is in the disable position, permanent storage of calibration constants will not take place. However, temporary calibration values may be entered and used even if permanent calibration storage is disabled. Note, however, that any calibration parameters will be lost once the power is turned off.

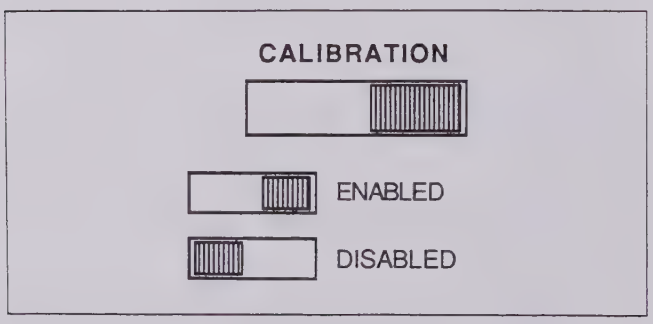


Figure 8-2. Calibration Switch

8.4.6 Calibration Record

Appendix G of this manual contains a calibration record for organizations that need to keep track of calibration results. The tables in this record are structured so that they can be used in place of the calibration tables in this section. If using the calibration record, make copies of the orignal form. The original form should not be written on or removed from this manual. If using the tables in this section, use a pencil for recording data. This allows the data to be erased so that the tables can be used again in the future.

8.4.7 Front Panel Calibration

Perform the following procedures if digital calibration is to be performed from the front panel. Calibration must be performed in the order that it is presented. Digital calibration (procedures A through C) is performed twice. "Cold" calibration is performed when the instrument is first turned on and "Hot" calibration is done after the instrument has thoroughly warmed up.

NOTE

Before proceeding, make sure the instrument has been off and in a calibration lab environment (see paragraph 8.4.3) for at least four hours. Once the following procedure is started, it must be completed within 24 hours.

A. Volts Calibration

NOTE

The first ("cold") calibration of the volts and ohms sources must be performed in less than 40 minutes.

1. Add the calibration program to the Model 263 menu by holding in the OPERATE button while turning the instrument on. Do not release the OPERATE button until the display blanks.
2. While waiting for the Model 263 to warm up for five minutes, connect the Model 263 to the Model 196 System DMM as shown in Figure 8-3.
3. While in standby, program the Model 263 for 190.000mV and set the Model 196 DMM to the 300mV range.
4. On the Model 263, press ZERO and then OPERATE to source 00.000mV to the DMM.
5. On the DMM, the offset of the Model 263 and the DMM will be displayed. To zero the display, thus cancelling the offset, press the ZERO button on the DMM.

NOTE

If using a DMM that does not have a zero suppress feature, record the offset reading. This value will have to be algebraically subtracted from the reading in the next step to determine the actual voltage sourced by the Model 263.

6. Press ZERO on the Model 263 to source the programmed voltage to the DMM. The reading on the DMM is the voltage sourced by the Model 263.
7. Record the output voltage value in Table 8-3 ("cold" cal) or Table 8-6 ("hot" cal).
8. The calibration value is derived from the output value as follows:
   A. The least significant digit (LSD) of the Model 263 display can only be programmed as a five or as a zero. Thus, the LSD of the calibration value has to be rounded to a five or zero. If the LSD of the 5½ digit output value is a one or two, replace it with a zero. For example, if the output value is 190.142mV, the calibration value will be 190.140mV. If the LSD of the output value is three through seven, replace it with a five. For example, if the output value is 189.877mV, the calibration value will be 189.875mV. If the LSD of the DMM reading is an eight or nine, change it to a zero and increment the next highest digit by one unit. For example, if the output value is 189.878mV, the calibration value will be 189.880mV.
   B. Record the calibration value in the Table 8-3 ("cold" cal) or in Table 8-6 ("hot" cal).
9. Select the Model 263 calibration program as follows:
   A. Press the MENU button to display the message "CAL".
   B. Release the MENU button. The exponent decimal points will turn on (not flashing) to indicate that the calibration program has been selected. Also, the cursor position is indicated by a flashing digit segment.
10. Using the adjust method, enter the calibration value on the display of the Model 263. The CURSOR buttons move the display cursor right and left, while the ADJUST buttons increment and decrement the display reading at the selected digit. Note that KEYPAD is inoperative while in the calibration program.
11. Calibrate the range by again pressing MENU. If the calibration switch is in the enable position the message "Stor" will be briefly displayed to indicate that the calibration constant was stored in NVRAM. If the message "out" is instead displayed followed by flashing exponent decimal points, then the calibration switch is in the disable position and calibration constants will be lost when the instrument is turned off. See paragraph 8.4.6 to set the calibration switch.

    Note: If there is no message ("Stor" or "out") briefly displayed when attempting to enter a calibration value, a problem exists and calibration will not occur. Also, flashing exponent decimal points with the calibration switch in the enabled position indicates a problem. Refer to paragraph 8.7 for servicing information.
12. Place the Model 263 in standby and disable the zero feature on the DMM.
13. Using Table 8-3 ("cold" cal) or Table 8-6 ("hot" cal) as a guide, repeat steps 3 through 12 for the 2V and 20V ranges.

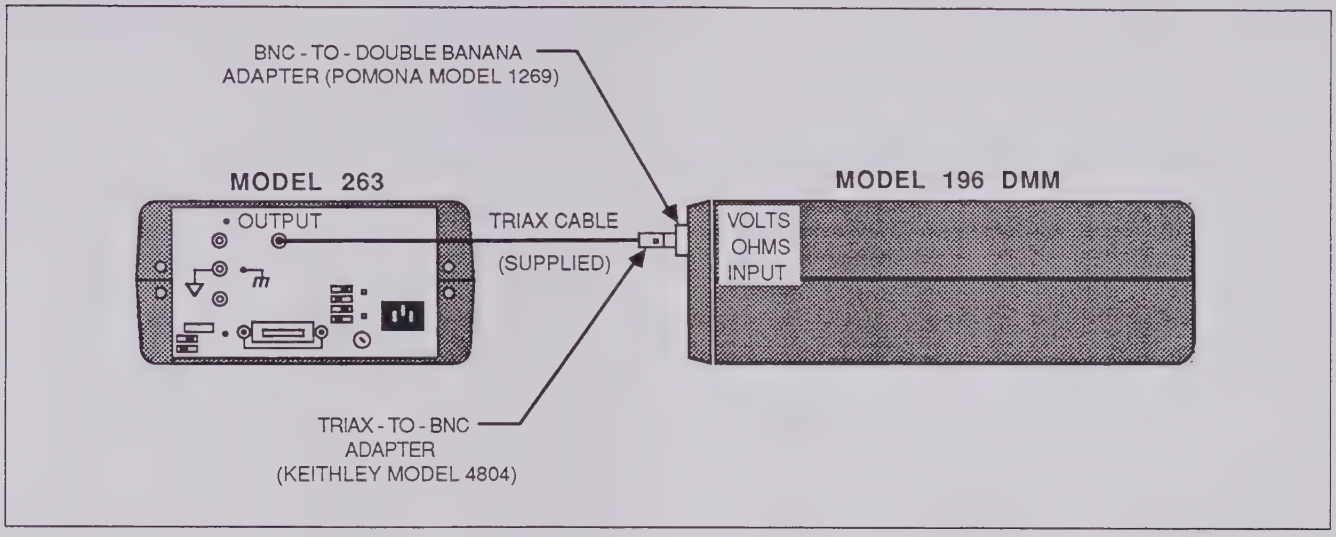


Figure 8-3. Volts and Low Ohms Calibration

B. Low Ohms (1kΩ through 1MΩ) Calibration

1. While in standby, set the Model 263 to the 1kΩ range and the DMM to the 3kΩ range.
2. On the Model 263 press ZERO and then OPERATE to source zero ohms to the DMM.
3. The offset reading on the DMM will be the result of cable resistance and zero offset. To zero the display, thus cancelling the offset, press the ZERO button on the DMM.

NOTE

If using a DMM that does not have a zero suppress feature, record the offset reading. This value will have to be algebraically subtracted from the reading in the next step to determine the actual resistance sourced by the Model 263.

4. Press ZERO of the Model 263 to source the resistor to the DMM. The reading on the DMM is the resistance sourced by the Model 263.
5. Record the resistance output value in Table 8-4 ("cold" cal) or Table 8-7 ("hot" cal). This 5½ digit reading is the calibration value.
6. Select the Model 263 calibration program by pressing the MENU button.
7. Using the Adjust method, enter the calibration value on the display of the Model 263 and then press the MENU button to calibrate and store the new value.
8. Place Model 263 in standby and disable the zero feature on the DMM.
9. Using the appropriate low ohms calibration table as a guide, repeat steps 2 through 8 for the 10kΩ range.
10. Using the appropriate low ohms calibration table as a guide, repeat steps 4 through 7 for the 100kΩ and 1MΩ ranges.

NOTE

If using the direct measurement method to calibrate high ohms, skip the following procedure (C). Instead, perform the following steps using Table 8-9 and 8-10 as a guide. Note that guarding should be used to measure the 100MΩ through 100GΩ resistors. Remember, Model 263 guard is toggled on and off by pressing SHIFT GUARD in that order. The GUARD indicator light on the front panel defines its status.

1. While in standby, set the Model 263 to the 10MΩ range.
2. On the Model 263, press OPERATE to source 10MΩ to the measurement instrument.
3. Record the actual resistance output value in Table 8-9 ("cold" cal) or Table 8-10 ("hot" cal). This reading is the calibration value.
4. Select the Model 263 calibration program by pressing the MENU button.
5. Using the Adjust Method, enter the calibration value on the display of the Model 263.
6. Press the Model 263's MENU button to calibrate and store the value.
7. Set the Model 263 to output 100MΩ, and perform steps 3 through 6 to calibrate the 100MΩ range.

8. Set the Model 263 to output 1GΩ and record the output value in Table 8-9 or 8-10.
9. Press Menu to select the calibration program.
10. Using the Adjust Method, enter the calibration value on the display of the Model 263.
11. If performing the "cold" calibration, press GUARD once to turn off one of the exponent decimal points. Otherwise, for "hot" calibration, proceed to the next step.
12. Press the MENU button to calibrate and store the value.
13. Repeat the basic procedure of steps 8 through 12 for the 10GΩ and 100GΩ resistors.

C. High Ohms (10MΩ through 100GΩ) Calibration ("Ladder" Technique)

1. Disconnect the triax cable from the 263 OUTPUT and connect the Model 263 PREAMP OUT to the DMM as shown in Figure 8-4.
2. Set the Model 263 to the 1kΩ range and the DMM to the 30V range. If the DMM has a filter, enable it. For the Model 196 DMM, use a filter value of 10. Unit must be in cal mode in order to place Model 263 in "ladder" configuration. Place unit in cal mode by turning unit off and then on while holding OPERATE button until display blanks.
3. Place the Model 263 in the "ladder" configuration by pressing the SHIFT button and then the OHMS button. The 1ML "ladder" range will be displayed as follows:

   1.00000 ML

   NOTE: If a different "ladder" range is displayed, press RANGE ▼ until the 1ML range is displayed.
4. Press ZERO and then OPERATE on the Model 263. The DMM will display the offset. Note: When calibrating the 10.0000GL and 100.000GL ranges, allow the reading on the DMM to settle for at least two minutes before proceeding.
5. To cancel the offset, allow the reading to settle and then press the ZERO button on the DMM.

   Note: If using a DMM that does not have a zero feature, record the settled offset reading. This value will have to be algebraically subtracted from the reading in the next step to determine the actual voltage from the preamp output.
6. Press ZERO on the Model 263. The reading on the DMM is the actual voltage (minus offset) from the preamp output.

   Note: When calibrating the 10.0000GL and 100.000GL ranges, allow the reading on the DMM to settle for at least two minutes before proceeding to the next step.
7. Record the output voltage value in Table 8-5 ("cold" cal) or Table 8-8 ("hot" cal).
8. The calibration value is derived from the output voltage value as follows:
   A. Ignore the decimal point position on the DMM reading. The decimal point position for the calibration value is determined by the "ladder" range of the Model 263. For example, on the 1.00000ML range, the calibration value derived from a DMM reading of 10.1200V would be 1.01200ML on the 30V range; 1.89933V would be 189.933ML on the 3V range; 189.933mV would be 1.89933GL on the 300mV range.
   B. Record the calibration value in Table 8-5 ("cold" cal) or Table 8-8 ("hot" cal).
9. Select the calibration program by pressing MENU.
10. Using the Adjust method, enter the calibration value on the display of the Model 263.
11. If "cold" calibrating the 1GL, 10GL or 100GL range, press the GUARD button. The first exponent decimal point will turn off.
12. To calibrate, again press the MENU button.
13. Disable the zero feature on the DMM.
14. Using the appropriate high ohms calibration table as a guide, repeat steps 2 through 12 for the 10ML, 100ML, 1GL, 10GL and 100GL "ladder" ranges.

D. "Hot" Calibration

After allowing the instruments to warm up for at least four additional hours, repeat the entire digital calibration procedure (Procedures A through C).

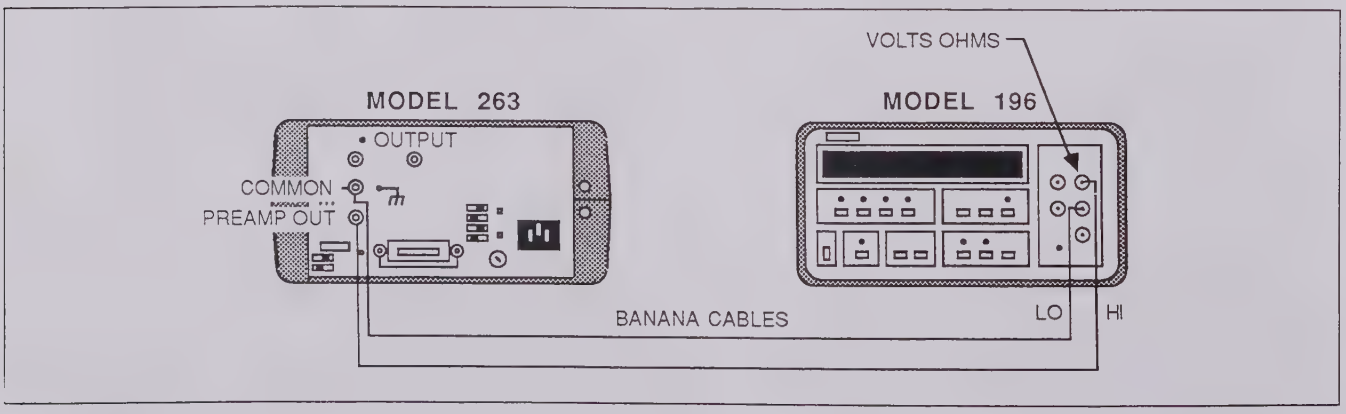


Figure 8-4. High Ohms Calibration and Voltage Offset Adjust

Table 8-3. "Cold" Volts Calibration

DMM Range	263 Programmed Output	Actual Voltage Output (DMM Reading)	263 Calibration Value
300mV	190.000mV	____.____mV	____.____mV
3 V	1.90000V	_._____ V	_._____ V
30 V	19.0000V	__.____ V	__.____ V

E. Offset Voltage Adjust

1. Cap the triax output connector.
2. Remove the two screws securing the top cover to the rear panel. Leave the cover on for now in order to maintain the internal temperature.
3. Select the 1.00000ML "ladder" range and set the DMM to the 30V range. The reading on the DMM will be approximately 15V.
4. On the Model 263, press ZERO and OPERATE in that order. The reading on the DMM will be the offset voltage of the Model 263.
5. Set the DMM to the 3V range and allow the reading to settle.
6. Remove the top cover of the Model 263 and adjust R9 (see Figure 8-5) for a reading of 0.00000V ±20μV.
7. Replace the top cover on the Model 263.

Table 8-4. "Cold" Low Ohms Calibration

DMM Range	263 Range	263 Calibration Value (DMM Reading)
3 kΩ	1 kΩ	_._____ kΩ
30 kΩ	10 kΩ	__.____ kΩ
300 kΩ	100 kΩ	____.___ kΩ
3MΩ	1MΩ	_._____MΩ

Table 8-5. "Cold" High Ohms Calibration

DMM Range	263 "Ladder" Range	Actual Voltage Output (DMM Reading)	263 Calibration Value
30 V	1.00000ML	__.____ V	_._____ML
30 V	10.0000ML	__.____ V	__.____ML
3 V	100.000ML	_._____ V	____.___ML
300mV	1.00000GL	____.____mV	_._____GL
3 V	10.0000GL	_._____ V	__.____GL
300mV	100.000GL	____.____mV	____.___GL

Table 8-6. "Hot" Volts Calibration

DMM Range	263 Programmed Output	Actual Voltage Output (DMM Reading)	263 Calibration Value
300mV	190.000mV	_____mV	_____mV
3 V	1.90000V	_._____ V	_._____ V
30 V	19.0000V	__._____ V	__._____ V

Table 8-7. "Hot" Low Ohms Calibration

DMM Range	263 Range	263 Calibration Value (DMM Reading)
3 kΩ	1 kΩ	_._____ kΩ
30 kΩ	10 kΩ	__._____ kΩ
300 kΩ	100 kΩ	_____ kΩ
3MΩ	1MΩ	_._____MΩ

Table 8-8. "Hot" High Ohms Calibration

DMM Range	263 "Ladder" Range	Actual Voltage Output (DMM Reading)	263 Calibration Value
30 V	1.00000ML	__._____ V	_._____ML
30 V	10.0000ML	__._____ V	__._____ML
3 V	100.000ML	_._____ V	_____ML
300mV	1.00000GL	_____mV	_._____GL
3 V	10.0000GL	_._____ V	__._____GL
300mV	100.000GL	_____mV	_____GL

Table 8-9. "Cold" High Ohms Calibration (Direct Measurement Method)*

263 Range	263 Guard	Measured Resistance (Calibration Value)
10MΩ	OFF	___._____MΩ
100MΩ	ON	____.____MΩ
1GΩ	ON	_._____GΩ
10GΩ	ON	___._____GΩ
100GΩ	ON	____.____GΩ

*Do not use this table if the "ladder" technique is used to calibrate the 10MΩ through 100GΩ ranges.

Table 8-10. "Hot" High Ohms Calibration (Direct Measurement Method)*

263 Range	263 Guard	Measured Resistance (Calibration Value)
10MΩ	OFF	___._____MΩ
100MΩ	ON	____.____MΩ
1GΩ	ON	_._____GΩ
10GΩ	ON	___._____GΩ
100GΩ	ON	____.____GΩ

*Do not use this table if the "ladder" technique is used to calibrate the 10MΩ through 100GΩ ranges.

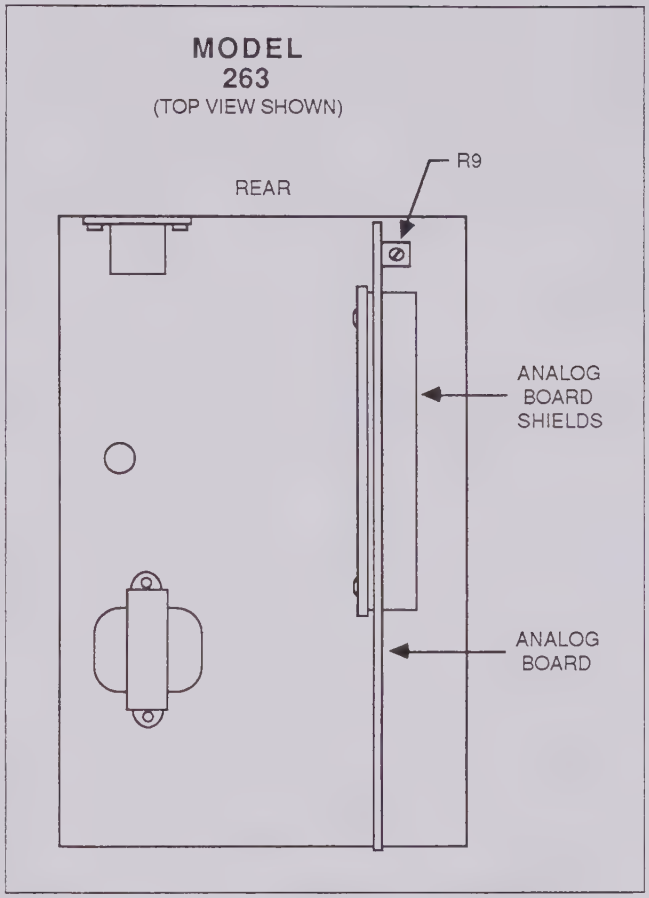


Figure 8-5. Offset Voltage Adjust

8.4.8 IEEE-488 Bus Calibration Program

Perform the following steps to calibrate the Model 263 using a Model 196 DMM. This automated program is controlled by an HP-85 computer that is equipped with the HP 82937 GPIB Interface and an I/O ROM.

1. Connect the Models 263 and 196 to the GPIB interface of the HP 85 computer.
2. Make sure the IEEE-488 address of the Model 263 is set to 8 and the address of the Model 196 is set to 7.
3. Enter the calibration program into the HP 85 computer.
4. To calibrate the Model 263, press the RUN key on the computer. The program will prompt for setups and automatically perform digital calibration. Lastly, the program will prompt for the only manual adjustment required.

```
10 CLEAR @ CLEAR 707,708 @ PRINT
20 REMOTE 707,708
30 CLEAR @ PRINT "CALIBRATION CONSTANTS"
40 CLEAR 707,708 @ PRINT
50 REMOTE 707,708
60 FOR K=1 TO 2
70 BEEP @ DISP "CONNECT 196 TO 263 OUTPUT (SEE  FIG 8-3)."
80 DISP @ DISP "PRESS CONT TO CONTINUE."
90 PAUSE
100 CLEAR @ IF K=1 THEN 130
110 PRINT @ PRINT "HOT CAL:"
120 PRINT @ GOTO 140
130 PRINT "COLD CAL:" @ PRINT
140 FOR I=1 TO 3
150 DATA .19,1.9,19
160 OUTPUT 707 ;"P0S2F0R";I;"X" ! 196: Select DCV range.
170 READ B
180 OUTPUT 708 ;"F2R0V";B;"X" ! 263: Program DCV for 190000 counts.
190 OUTPUT 708 ;"Z1O1X" ! 263: Source 0V.
200 WAIT 3000
210 OUTPUT 707 ;"Z1X" ! 196: Enable ZERO.
220 OUTPUT 708 ;"Z0X" ! 263: Source 190000 DCV counts.
230 WAIT 3000
240 ENTER 707 ; A ! 196: Send reading to computer.
250 OUTPUT 708 ;"A";A;"X" ! 263: Recieve cal value.
260 ENTER 708 ; A$ ! 263: Send cal value to computer.
270 PRINT " ";A$ ! Print cal value
280 WAIT 2000
290 NEXT I @ PRINT
300 FOR J=1 TO 4
310 DATA 2,3,4,5
320 OUTPUT 708 ;"F0R";J;"X" ! 263: Select ohms range.
330 IF J>2 THEN 350
340 OUTPUT 708 ;"Z1X" ! 263: Set to 0ohms.
```

CALIBRATION PROGRAM

```
350 READ C
360 OUTPUT 708 ;"D1X" ! 263; Source 0ohms.
370 OUTPUT 707 ;"F2R";C;"X" ! 196; Select ohms range.
380 OUTPUT 707 ;"Z0X" ! 196; Disable ZERO.
390 WAIT 3000
400 IF J>2 THEN 450
410 OUTPUT 707 ;"Z1X" ! 196; Enable ZERO.
420 WAIT 3000
430 OUTPUT 708 ;"Z0X" ! 263! Source resistor.
440 WAIT 3000
450 ENTER 707 ; A ! 196; Send reading to computer.
460 OUTPUT 708 ;"A";A;"X" ! 263; Recieve cal value.
470 ENTER 708 ; A$ ! 263; Send cal value to computer.
480 PRINT " ";A$ ! Print cal value.
490 WAIT 2000
500 NEXT J
510 PRINT @ DISP "CONNECT 196 TO PREAMP OUT (SEE  FIG 8-4)." @ DISP
520 BEEP @ DISP "PRESS CONT TO CONTINUE."
530 PAUSE
540 FOR H=1 TO 6 @ CLEAR
550 DATA 3,3,2,1,2,1
560 READ D
570 OUTPUT 707 ;"P10Z0F0R";D;"X" ! 196; Enable filter, select DCV range.
580 OUTPUT 708 ;"F8R";H;"X" ! 263; Select ladder range.
590 OUTPUT 708 ;"Z1O1X" ! 263; Source zero.
600 DISP "WAITING FOR READING TO SETTLE!"
610 WAIT 15000
620 IF H>4 THEN 640
630 GOTO 650
640 WAIT 120000
650 OUTPUT 707 ;"Z1X" ! 196; Enable ZERO.
660 WAIT 2000
670 OUTPUT 708 ;"Z0X" ! 263; Source ladder.
680 WAIT 15000
690 IF H>4 THEN 710
700 GOTO 720
710 WAIT 120000
720 ENTER 707 ; A ! 196; Send reading to computer.
730 IF H=1 THEN 790
740 IF H=2 THEN 810
750 IF H=3 THEN 830
760 IF H=4 THEN 850
770 IF H=5 THEN 850
780 IF H=6 THEN 870
790 A=A/10*10^6
800 GOTO 880
```

CALIBRATION PROGRAM (Cont.)

```
810 A=A*10^5
820 GOTO 880
830 A=A*10^6
840 GOTO 880
850 A=A*10^10
860 GOTO 880
870 A=A*10^12
880 IF K=2 THEN 930
890 IF H>3 THEN 920
900 OUTPUT 708 ;"A";A;"X" ! 263; Recieve cal value.
910 GOTO 930
920 OUTPUT 708 ;"L";A;"X" ! 263; Recieve "cold" Gohm cal value.
930 WAIT 2000
940 ENTER 708 ; A$ ! 263; Send cal value to computer.
950 PRINT " ";A$ ! Print cal value.
960 NEXT H
970 CLEAR
980 IF K=2 THEN 1030
990 DATA .15,1.8,19,2,3,4,5,3,3,2,1,2,1
1000 DISP "WAIT FOR 3 HOURS"
1010 BEEP @ DISP @ DISP "PRESS CONT FOR 'HOT' CAL"
1020 PAUSE
1030 CLEAR @ NEXT K
1040 OUTPUT 708 ;"R1X" ! 263; Select 1ML range.
1050 OUTPUT 707 ;"Z0^F3X" ! 195; Select 30V range.
1060 WAIT 5000
1070 OUTPUT 708 ;"Z101X" ! 263; Source zero.
1080 BEEP @ DISP "CAP 263 OUTPUT." @ DISP
1090 DISP "REMOVE 263 TOP COVER." @ DISP
1100 DISP "ADJUST R___ (FIG. 5-8) FOR      00.0000V ON 195"
1110 DISP @ DISP "CALIBRATION COMPLETED"
1120 END
```

CALIBRATION PROGRAM (Cont.)

8.5 SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

CMOS devices operate at very high impedance levels for low power consumption. As a result, any static charge that builds up on your person or clothing may be sufficient to destroy these devices, if they are not handled properly. Use the precautions below to avoid damaging them.

1. ICs should be transported and handled only in containers specially designed to prevent static build-up. Typically, these parts will be received in anti-static containers of plastic or foam. Keep these devices in their original containers until ready for installation.
2. Remove the devices from their protective containers only at a properly grounded work strap.
3. Handle the devices only by the body; do not touch the pins.
4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table.
5. Use only anti-static type solder sucker.
6. Use only grounded tip soldering irons.
7. Once the device is installed on the PC board, it is normally adequately protected, and normal handling can resume.

8.6 DISASSEMBLY INSTRUCTIONS

If it is necessary to troubleshoot the instrument or replace a component, use the following disassembly procedure. An exploded view of the instrument may be found in Figure 8-6.

WARNING
Disconnect the line cord and any cables from the instrument before disassembly.

1. Remove the top cover as follows:
   A. Remove the two screws that secure the top cover to the rear panel.
   B. Grasp the top cover at the rear and carefully pull up until the tabs at the front of the cover clear the front panel. The cover may then be pulled completely clear.
   C. To replace the top cover, reverse the above procedure. Be sure to install the tabs at the front of the cover before completely installing it. Also, make sure the spring contact clips located on the rear panel make contact with the top cover shield.
2. Remove the analog board as follows:
   A. Disconnect P10 and P11 from the analog board. P10 leads to the OUTPUT connecter and P11 leads to PREAMP OUT and EXT INPUT.

      NOTE: There may be another cable connector (P12) located near the front of the analog board. If so, disconnct P12 from the analog board.

   B. Grasping the analog board by the guarded shield, carefully lift the analog board shield out of the instrument.

      Note: When reinstalling the analog board, make sure the board is installed in the card edge guides (located at the front and rear of the instrument) so that the analog board mates properly with the mother board.
   C. To remove the guarded shield from the analog board, remove the eight screws securing the shield to the board standoffs. Four screws secure the top (component) part of the shield to the board and four screws secure the bottom part.

CAUTION
Do not touch the PC board or any component that is in the shielded area of the anloag board. Contamination in this high impedance area will result in degraded instrument performance. In the event of component replacement or inadvertent contamination, clean the board per instructions in paragraph 8-8.

3. Remove the mother board as follows:
   A. Using an IC puller, disconnect the display board ribbon cable (near the front of the instrument) from the mother board.
   B. Remove the six screws and collars securing the mother board to the bottom case.
   C. Remove the two screws that secure the rear panel to the bottom case and remove the mother board and rear panel as a single unit.
   D. The voltage source shield can be removed by removing the four screws that secure it the mother board.

CAUTION
Do not touch the board or any components in the shielded area. Contamination in this area may result in degraded instrument performance. If contamination occurs, clean the area as described in paragraph 8-8.

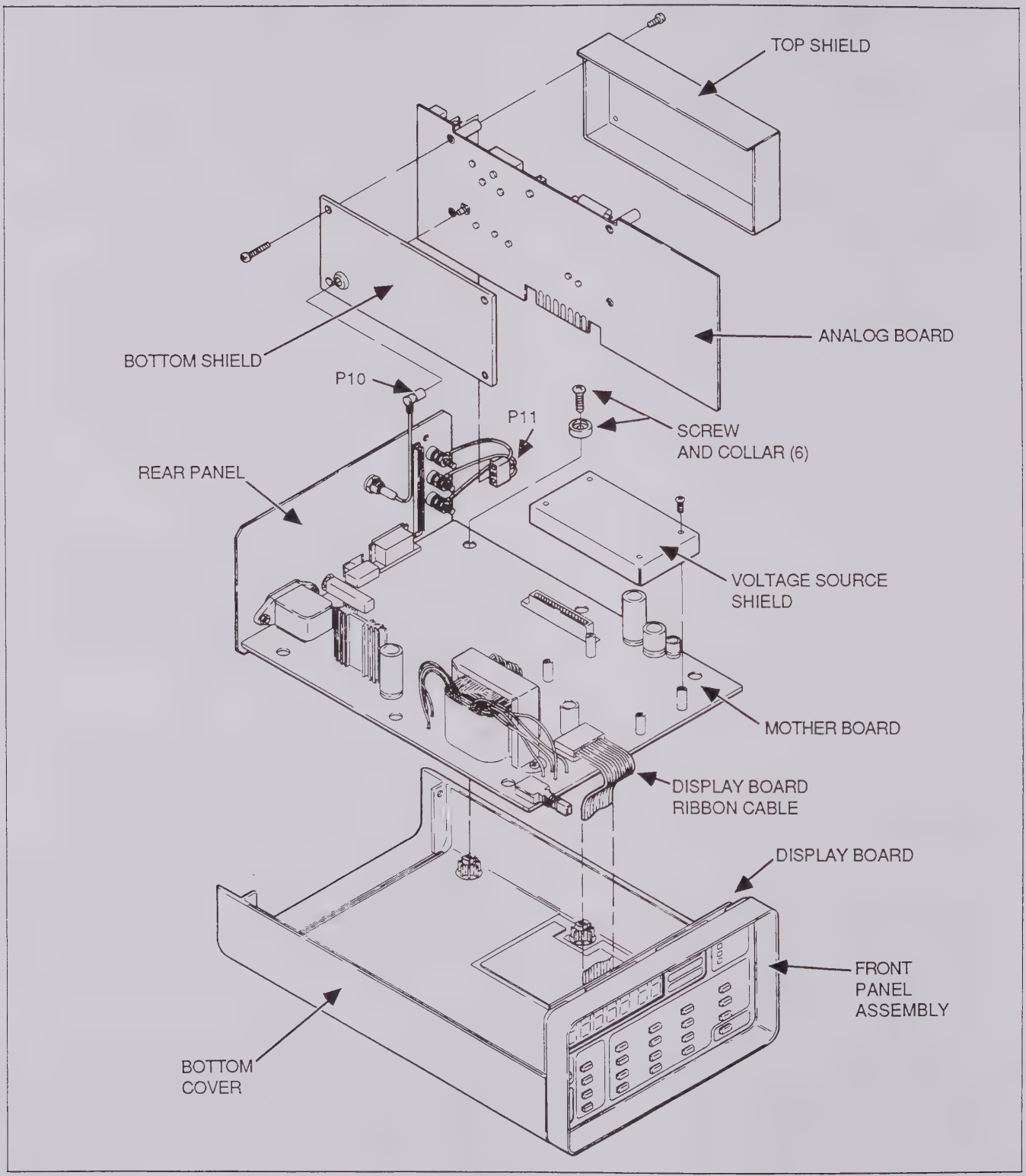


Figure 8-6. Model 263 Exploded View

Note: When reinstalling the mother board assembly, make sure that all the spring contact clips make contact with their respective shields. There is one spring contact clip located on the trace side of the mother board and two clips on the rear panel.

4. The display board can now be removed as follows:
   A. Remove the two screws that secure front panel assembly to the bottom case. These screws are located near the bottom of the display PC board.
   B. Carefully slide the front panel assembly upward (along the grooves in the sides of the bottom case) away from the bottom case.

      Note: When reinstalling the front panel assembly, make sure the bottom edge of the display PC board seats between the guide tabs located on the bottom case.

   C. To remove the display board, remove the two screws securing it to the front panel assembly.

      Note: When reinstalling the front panel assembly, make sure the spring contact clip is making contact with the display board shield and and the bottom case shield.
5. The instrument can be re-assembled by reversing the above procedure. Make sure that all boards are properly seated and secured, and that all connections are properly made. To ensure proper operation, shields must be replaced and fastened securely.

WARNING

To ensure continued protection against safety hazards, power line ground must be connected to the rear panel. This connection is made by the two kep nuts securing the AC power receptacle to the rear panel. Make sure that these nuts are securely installed before applying power to the instrument.

8.7 TROUBLESHOOTING

The troubleshooting information contained in this section is intended for qualified personnel having a basic understanding of analog and digital circuitry. The individual should also be experienced at using typical test equipment, as well as ordinary troubleshooting procedures. The information presented here has been written to assist in isolating a defective circuit or circuit section. Isolation of the specific component is left to the technician. Note that schematic diagrams and component layout drawings, which are an essential aid in troubleshooting, are located at the end of Section 9.

8.7.1 Recommended Test Equipment

Success in troubleshooting complex equipment like the Model 263 depends not only on the skill of the technician, but also relies on the use of accurate, reliable test equipment. Table 8-11 lists the minimum recommended equipment for troubleshooting the the Model 263. Other equipment such as logic analyzers and capacitance meters could also be helpful, especially in difficult situations.

8.7.2 Power Up Self Test

Upon power up, the Model 263 will automatically test its RAM and ROM memory, and check for proper calibration constants. If a RAM error occurs, the following message will remain on the display:

r.r.

If a ROM error occurs, the following message will remain on the display:

r.o.

Table 8-11. Recommended Troubleshooting Equipment

Equipment	Use
DMM with 0.015% basic DC accuracy, 10MΩ input impedance (Keithley Model 196 or equivalent).	Power supply and DC voltage checks; analog signal tracing; continuity; static logic levels.
Storage oscilloscope, DC-50MHz bandwidth.	Digital and analog waveform checks.

With either error, the instrument will be completely inoperative. In the event of a ROM error try replacing U47 and for a RAM error, try replacing U46.

If a calibration error occurs, the two exponent decimal points will flash. The instrument will be functional under these conditions, but calibration is not accurate. Use the calibration procedures in paragraph 8-4 of this section to calibrate the instrument. If an NVRAM error persists after calibration, then the NVRAM may be defective. Try replacing U15 and U41.

8.7.3 Display Test and Software Revision

This test displays all digit segments allowing the user to check for defects and displays the current revision level of the software installed in the unit. Perform the following steps as follows:

1. Turn on the instrument while holding in the COUL button. The normal power up tests on RAM, ROM, and NVRAM will be performed (see paragraph 8.8.1) and then all display segments and indicators will turn on and remain on as long as the COUL button is held in.
2. Release the COUL button. The software revision level will be displayed briefly. For example, if the software revision level is Al, then the following message will be displayed briefly:

   A1

   The instrument will now display a value terminated with a "T". This number represents temperature information and should be between 25,000 and 45,000. A value outside of this range indicates a problem with the temperature compensation circuitry.
3. To return to normal operation, turn the instrument off and then on again.

8.7.4 Power Supply Checks

All power supply voltages should be checked first to make sure they are within the required limits. If the various operating voltages are not within the required limits, troubleshooting the remaining circuitry can be quite difficult.

Table 8-12 outlines the various power supply voltages that should be checked. In addition to the usual voltage checks, it is a good idea to check the various supplies with an oscilloscope to make sure that no noise or ringing is present.

Table 8-12. Power Supply Checks

Step	Item/Component*	Required Condition	Remarks
1	S2	Set as required	Line voltage selection.
2	F1	Check for continuity	
3	Line power	Connect line power and turn on	
4	±V supplies	±22V nominal	Referenced to analog common ⏚A
5	+17V supply	17V ±15%	Referenced to signal common ⏚S
6	-24V supply	-24V ±15%	Referenced to signal common ⏚S
7	+5V supply	5V ±10%	Referenced to digital common ⏚D
8	+10.6V REF	10.6V ±10%	Referenced to signal common ⏚S
9	+6V supply	6V ±15%	Referenced to digital common ⏚d
10	-5V supply	-5V ±5%	Referenced to digital common ⏚d

*Item/Components are located on the mother board.

8.7.5 Logic and Switching FET States

Tables 8-13 through 8-15 list the logic levels for the various operating functions and ranges of the instrument. Also included are the FETs that are subsequently energized. Logic level 1 is >5V, while a logic level 0 is approximately 0V. All logic checks are referenced to digital common (d). The Model 263 must be in OPERATE when making these checks. The exception is the coulombs functions, which can be in STANDBY.

Table 8-13. Volts Logic and Switching States

263* Output	U9 & U10** Outputs		U11** Outputs								Range FETs** Energized	Polarity FETs Energized	Relays*** Energized
	Data		Range			0V	Polarity						
	Q1-Q8	Q1-Q8	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8			
00.000mV	1	1	1	0	1	0	1	1	0	0	Q9,Q11,Q14	Q5, Q7	K2, K8, K13
.00000V	1	1	1	1	0	0	1	1	0	0	Q12, Q13	Q5, Q7	K2, K8, K13
0.0000V	1	1	0	1	1	0	1	1	0	0	Q10	Q5, Q7	K2, K8, K13
>0V (+)	•	•	•	•	•	1	1	1	0	0	•	Q5, Q7	K2, K8, K13
<0V (−)	•	•	•	•	•	1	0	0	1	1	•	Q6, Q8	K2, K8, K13
VOLTS EXT	•	•	•	•	•	•	•	•	•	•	•	•	K2, K8, K13

1 = >5V, 0= ≈0V
• Not Applicable
All logic levels referenced to ▽d
*263 must be in OPERATE
**Located on mother board
***Located on analog board

Table 8-14. Amps and Coulombs Logic and Switching States

263 Function/ Range/Control		U11** Outputs			U1*** Outputs								U2*** Outputs								U7*** Outputs				FETs Energized		Relays***
AMPS*	COUL	Q1	Q2	Q3	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	Q1	Q2	Q3	Q4	Mother Board	Analog Board	Energized
20mA	—	0	1	1	0	1	0	0	•	0	0	1	0	1	0	0	0	0	•	0	0	•	1	0	Q10		K8, K11, K12
2mA	—	0	1	1	0	0	1	0	•	0	0	0	0	1	0	1	0	0	•	0	0	•	1	0	Q10		K3, K5, K8
200 μA	200μC	1	1	0	0	0	1	0	•	0	0	0	0	1	0	1	0	0	•	0	0	•	1	0	Q12, Q13		K3, K5, K8
20 μA	20 μC	1	1	0	0	0	0	1	•	0	0	0	0	1	0	1	0	0	•	0	0	•	1	0	Q12, Q13		K4, K5, K8
2 μA	2 μC	1	1	0	0	0	0	0	•	0	0	0	0	1	0	1	0	0	•	0	0	•	1	0	Q12, Q13		K5, K8
200nA	200nC	1	1	0	0	0	0	0	•	0	0	0	1	0	0	1	1	0	•	0	1	•	1	1	Q12, Q13	Q7, Q8	K5, K6, K7
20nA	20nC	1	1	0	0	0	0	0	•	0	0	0	0	0	1	1	0	1	•	0	0	•	1	0	Q12, Q13		K5, K9, K10
2nA	2nC	1	1	0	0	0	0	0	•	0	0	0	1	0	0	1	0	0	•	0	1	•	1	1	Q12, Q13	Q7, Q8	K5, K6
200pA	200pC	1	1	0	0	0	0	0	•	0	0	0	0	0	1	1	0	0	•	0	0	•	1	0	Q12, Q13		K5, K9
20pA	20pC	1	1	0	0	0	0	0	•	0	0	0	0	0	0	1	0	0	•	0	0	•	1	0	Q12, Q13		K5
2pA	—	1	0	1	0	0	0	0	•	0	0	0	0	0	0	1	0	0	•	0	0	•	1	0	Q9, Q11, Q14		K5
AMPS V/R, COUL V/R		•	•	•	•	•	•	•	•	1	•	•	•	•	•	0	•	•	•	•	•	•	0	•	•	•	K13
GUARD ON		•	•	•	•	•	•	•	0	•	•	•	•	•	•	•	•	•	1	•	•	•	•	•	•	•	
GUARD OFF		•	•	•	•	•	•	•	1	•	•	•	•	•	•	•	•	•	1	•	•	•	•	•	•	•	K14

1 = >5V, 0= ≈0V
• = Not Applicable

All logic levels referenced to ▽d

*263 must be in OPERATE
**Located on mother board
***Located on analog board

Table 8-15. Ohms Logic and Switching States*

263 Output** (Nominal)	U1 Outputs 1 2 3 4 5 6 7 8	U2 Outputs 1 2 3 4 5 6 7 8	U7 Outputs Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8	Relays Energized	FETs Energized
1 kΩ	0 1 0 0 • 1 0 1	0 1 0 0 0 0 0 0	0 • • 0 0 0 0 •	K12, K13, K11, K8	
10 kΩ	0 0 1 0 • 1 0 1	0 1 0 0 0 0 0 0	0 • • 0 0 0 0 •	K3, K13, K11, K8	
100 kΩ	0 0 0 1 • 1 0 1	0 1 0 0 0 0 0 0	0 • • 0 0 0 0 •	K4, K13, K11, K8	
1MΩ	0 0 0 0 • 1 0 1	0 1 0 0 0 0 0 0	0 • • 0 0 0 0 •	K13, K11, K8	
10MΩ	0 0 0 0 • 1 0 1	1 0 0 0 1 0 0 0	1 • • 1 0 0 0 •	K13, K11, K6, K7	Q7, Q8
100MΩ	0 0 0 0 • 1 0 1	0 0 1 0 0 1 0 0	0 • • 0 0 0 0 •	K13, K11, K9, K10	
1GΩ	0 0 0 0 • 1 0 1	1 0 0 0 0 0 0 0	1 • • 1 0 0 0 •	K13, K11, K6	Q7
10GΩ	0 0 0 0 • 1 0 1	0 0 1 0 0 0 0 0	0 • • 0 0 0 0 •	K13, K11, K9	
100GΩ	0 0 0 0 • 1 0 1	0 0 0 0 0 0 0 0	0 • • 0 0 0 0 •	K13, K11	
0 Ω	1 0 0 0 • 1 0 1	0 1 0 0 0 0 0 0	0 • • 0 0 0 0 •	K2, K13, K11, K8	Q8
GUARD ON	• • • • 0 • • •	• • • • • • • •	• • • • • • • •	•	
GUARD OFF	• • • • 1 • • •	• • • • • • • •	• • • • • • • •	•	

1 = >5V, 0 = ≈0V
• = Not Applicable

All logic levels referenced to ⏚

*All devices located on analog board.
**263 must be in OPERATE.

8.7.6 Voltage Source Checks

Check out the operation of the voltage source by using the procedure in Table 8-16. For these checks, program the Model 263 to output 1.00000V.

8.7.7. Electrometer Amplifier Check

Perform the steps in Table 8-17 to check out the electrometer amplifier circuitry. Set up the AMPS source of the Model 263 to output 10.0000mA to a 1kΩ resistor. Note that the voltage checks are referenced to analog common (A). The COMMON terminal on the rear panel is analog common.

8.7.8 Digital and Display Circuitry Checks

Check the various components associated with the digital and display circuitry using the procedures given in Table 8-18 and 8-19.

Table 8-16. Voltage Source Checks*

Step	Item/Component**	Required Condition	Remarks	Reference
1	TE5, TE18, P9 pin 14	+1.0000V	Programmed output	Analog common (A)
2	Junction R34 & R35	+5V	Filtered pulse width modulation (PWM) output	Signal common (S)
3	Junction R12 & R13	See Waveform 1	PWM output	Signal common (S)
4	U5 pin 8	See Waveform 2	PWM	Digital common (d)
5	U5 pin 9	See Waveform 3	PWM	Digital common (d)
6	U20 pin 8	See Waveform 4	PWM	Digital common (d)
7	U34 pin 5	See Waveform 5	Typical data	Digital common (d)

*Model 263 programmed to output 1.00000V.
**Item/Components for step 1 are located on the analog board. The rest are located on the mother board.

Table 8-17. Electrometer Amplifier Checks

Step	263 Output (Amps)	Load Resistor	Item/Component*	Required Condition	Remarks
1	10.0000mA	1kΩ	PREAMP OUT	≈10V	Amplifier gain (X1) check
2	10.0000mA	1kΩ	U9 and U10; pin 7	≈17.0V	$V_{PREAMP\ OUT} + V_{VR2} - V_{Q3}$
3	10.0000mA	1kΩ	U9 and U10; pin 4	≈3.0V	$V_{PREAMP\ OUT} - V_{VR1} + V_{Q4}$

*Item/Components are located on the analog board

Table 8-18. Digital Circuitry Checks

Step	Item/Component*	Required Condition**	Remarks
1	U14 pin 40	5V ±10%	5V digital supply
2	U14 pin 2	Waveform 6	Interrupt clock
3	U14 pin 1	Stays low for <1 sec on power-up, then goes high (≈5V).	MPU Reset
4	U14 pin 4	Waveform 7	Data strobe
5	U14 pin 6	Waveform 8	Address strobe

*Located on mother board.

**Referenced to digital common ▽D

Table 8-19. Display Circuitry Checks

Step	Item/Component*	Required Condition**	Remarks
1	U2 pin 9	5V ±10%	5V supply
2	U1, U2 pins 11-18	Waveform 9	Segment drivers
3	U5 pins 11-18 U6 pins 15-18	Waveform 10	Digit drivers
4	U4 pins 10-15	Waveform 11	Digit Multiplexer
5	P8 pin 14	Depress button on S0 lines and observe Waveform 12	Pulse present when button pressed.
6	P8 pin 15	Depress button on S1 line and observe Waveform 12	Pulse present when button pressed
7	P8 pin 16	Depress button on S2 line and observe Waveform 12	Pulse present when button pressed.

*Located on display board.

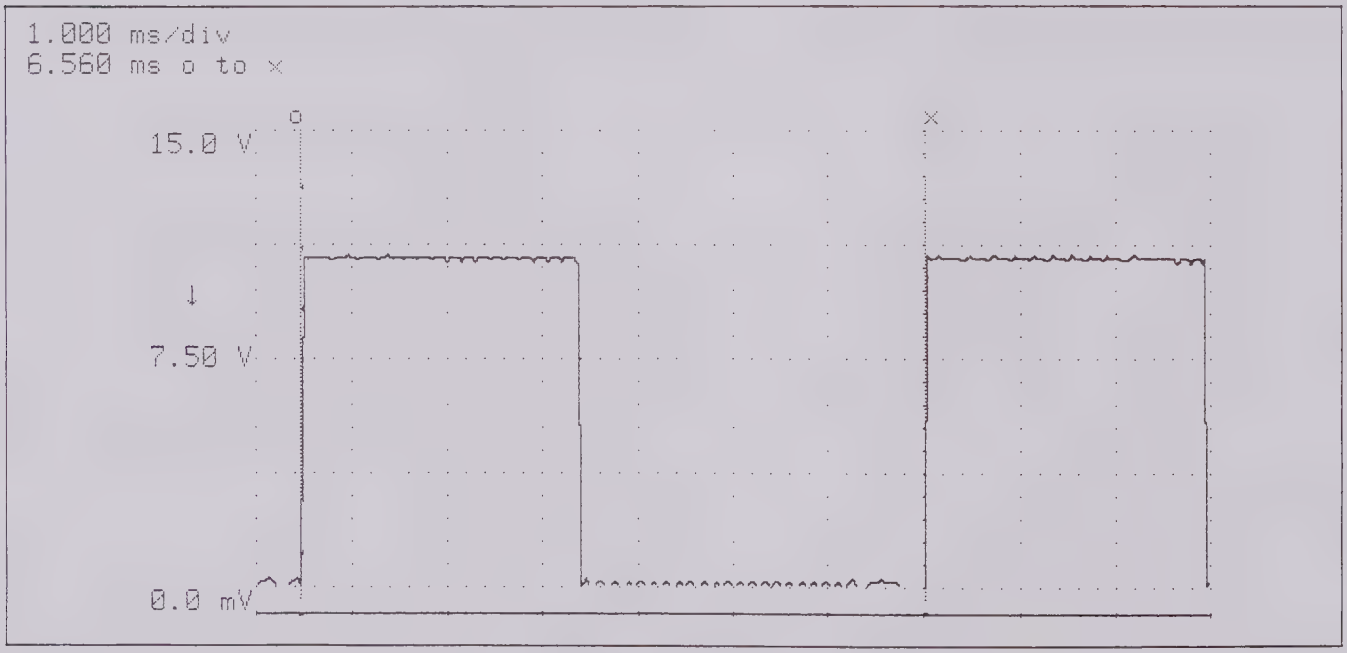
**Referenced to digital ground ▽D

8.8 HANDLING AND CLEANING PRECAUTIONS

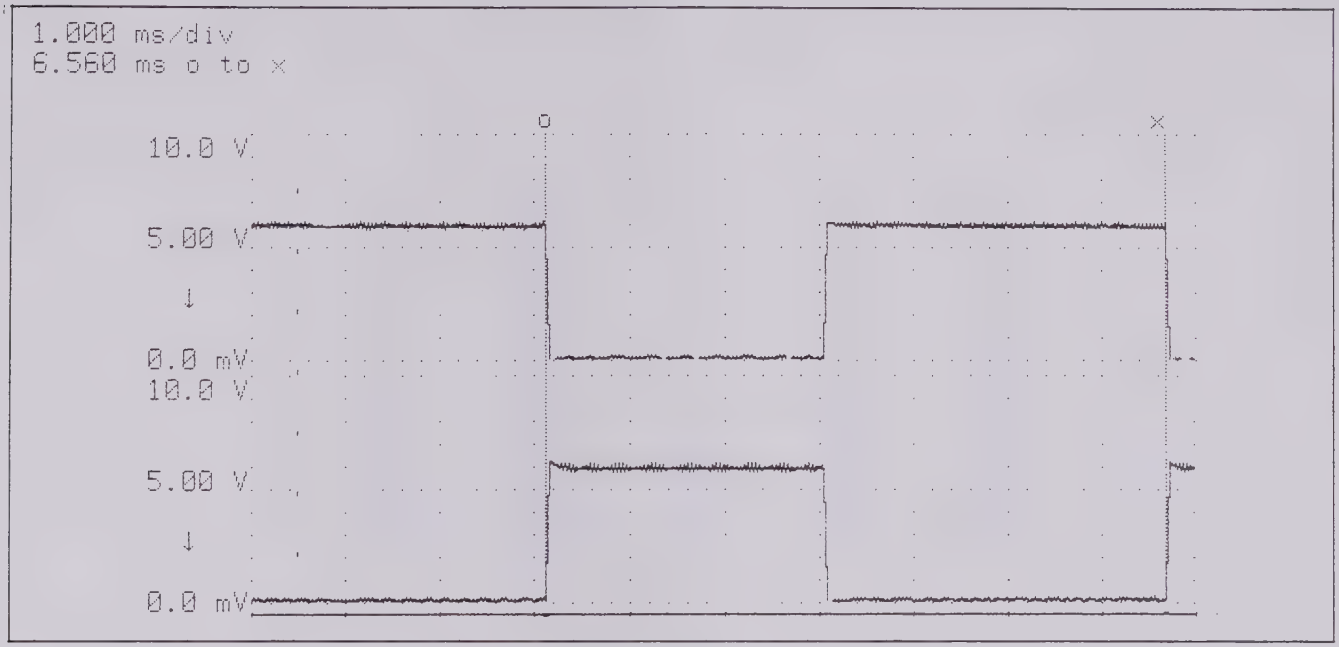
When troubleshooting or otherwise working inside the instrument, care should be taken not to indiscriminately touch PC board traces and open wires to avoid contaminating them with body oils or other foreign matter. In particular, there are two areas within the Model 263 that have high impedance devices or sensitive circuitry where contamination could cause degraded performance. These include the shielded area on the analog board and shielded area on the mother board.

The same general precautions apply when replacing parts in these areas. When unsoldering and soldering parts, be careful not to spread the flux around the board to adjacent areas.

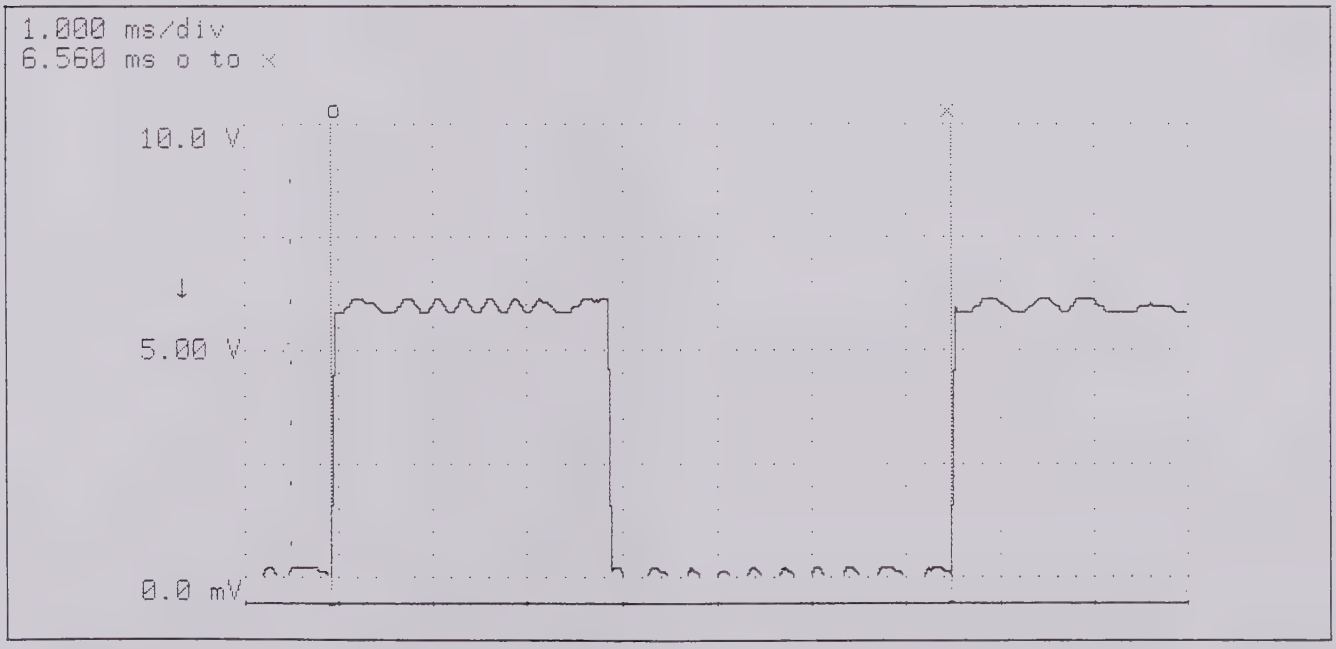
1. Using a squeeze bottle, carefully apply clean, uncontaminated methanol to the area to be cleaned. Use sufficient solution to thoroughly wet the circuit board.
2. Using a small, clean brush, wipe the area thoroughly until it is free of flux or contaminants. In some cases, it may be helpful to tilt the board at an angle and brush contaminants away from the affected area, allowing contaminated residue and methanol to run off the board.
3. Wash the area again with fresh, clean methanol, allowing it to drain, flushing contaminants off the board.
4. Once the area is thoroughly cleaned, it should be dried with pressurized dry clean air or nitrogen. Do not use compressed air from an ordinary air compressor, as oil particles in the air could contaminate the circuit board.
5. After cleaning or parts replacement check to see that any components connected to the Teflon insulators are not physically touching the board or adjacent parts.



WAVEFORM 1



WAVEFORMS 2 and 3



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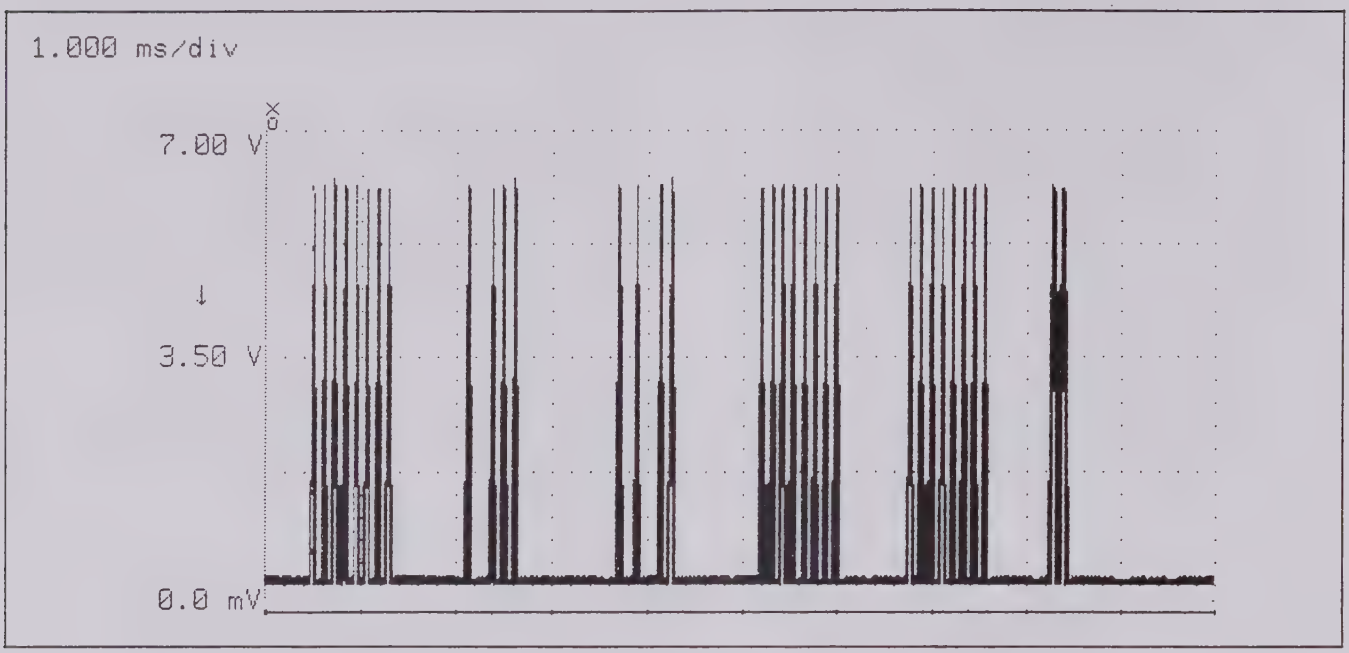
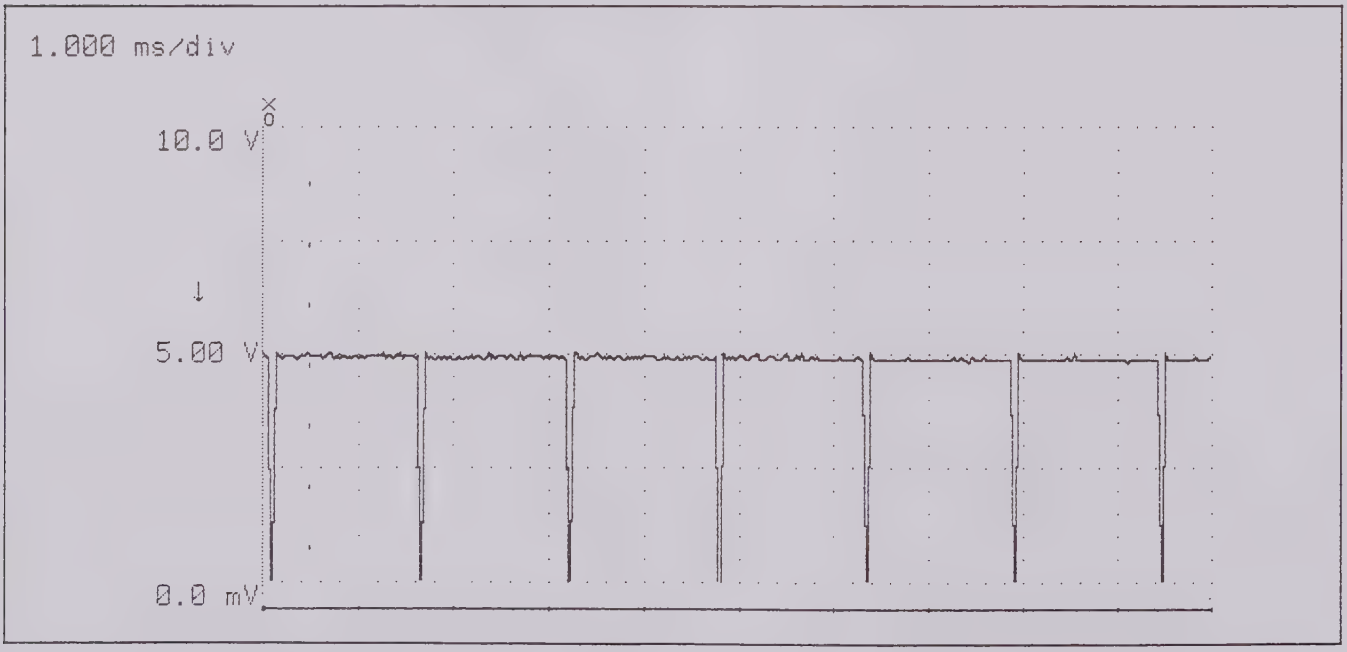


WAVEFORM 5



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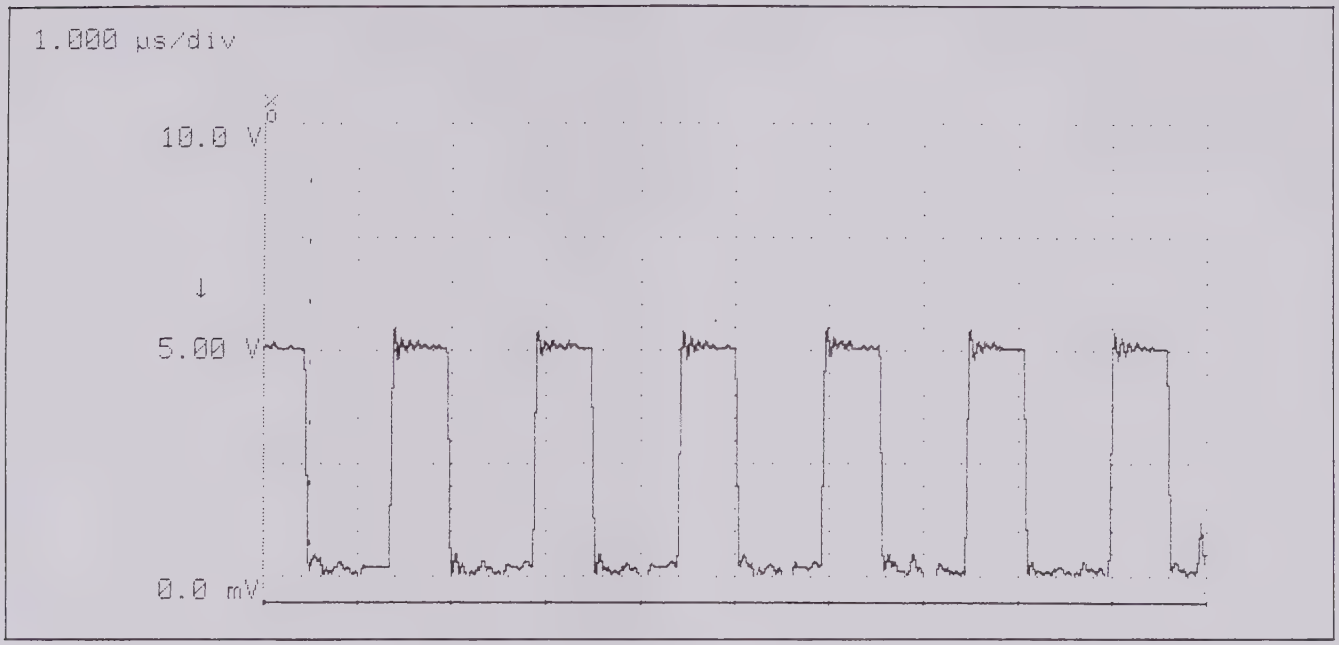

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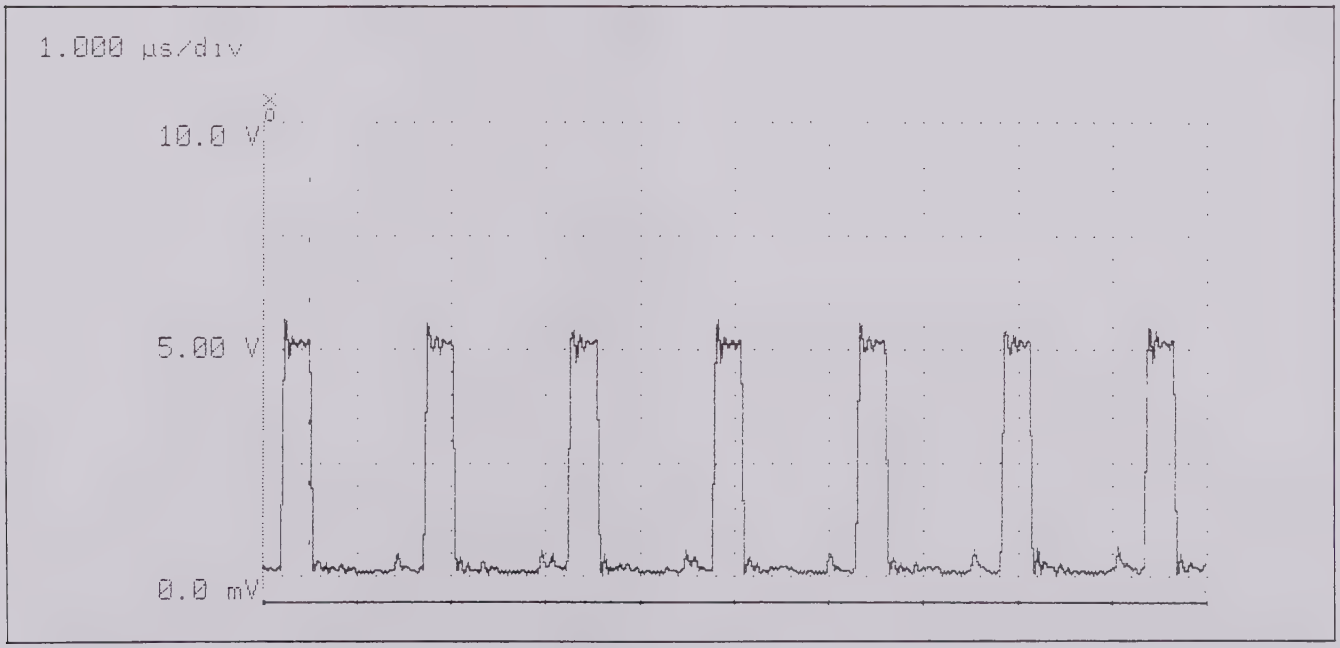
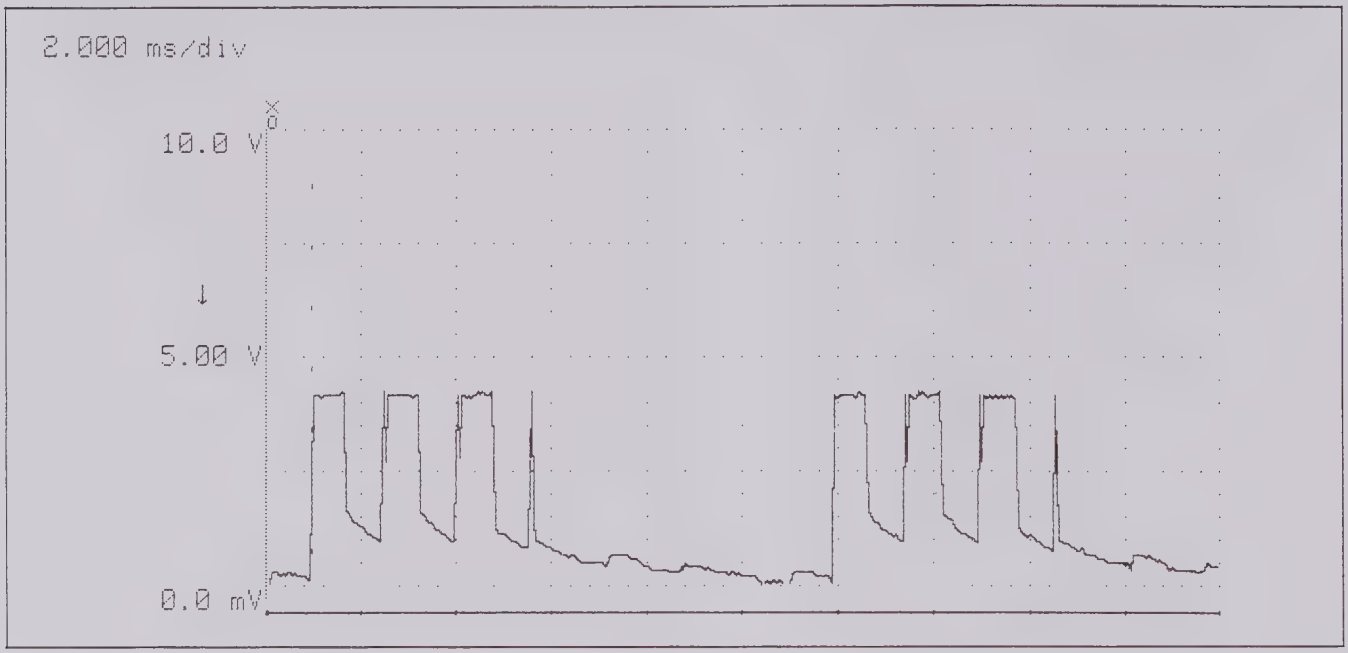


WAVEFORM 8



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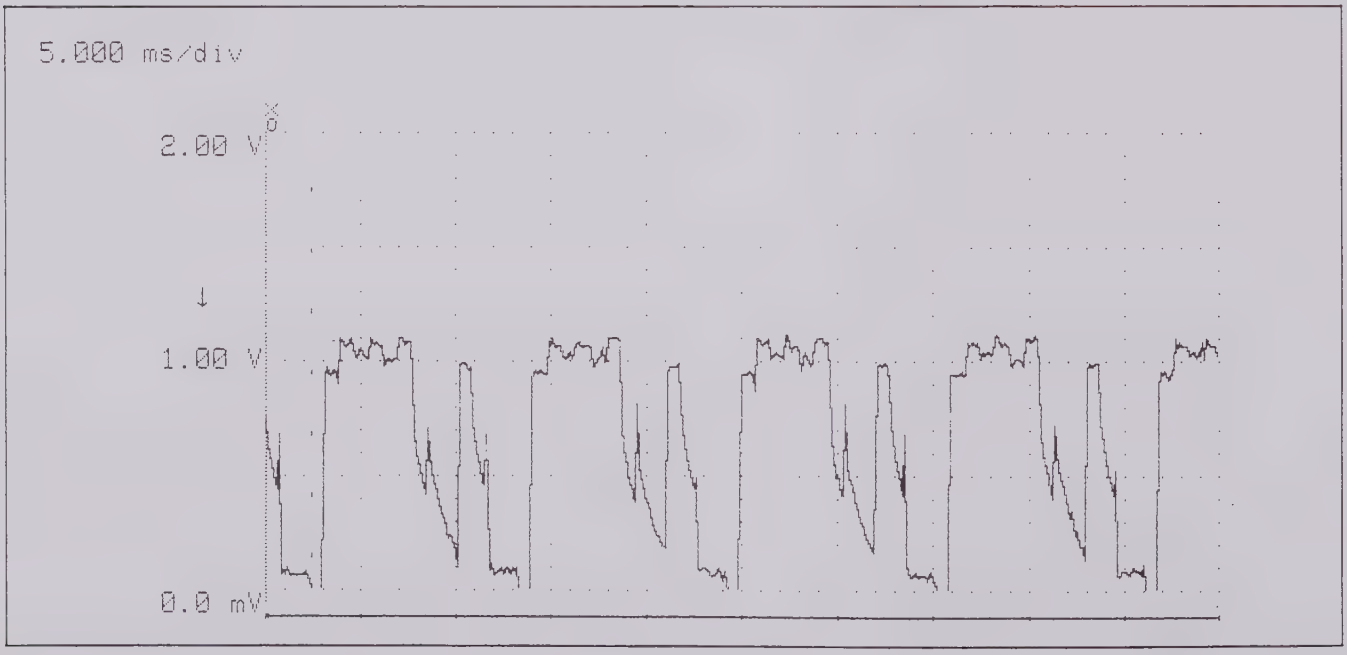
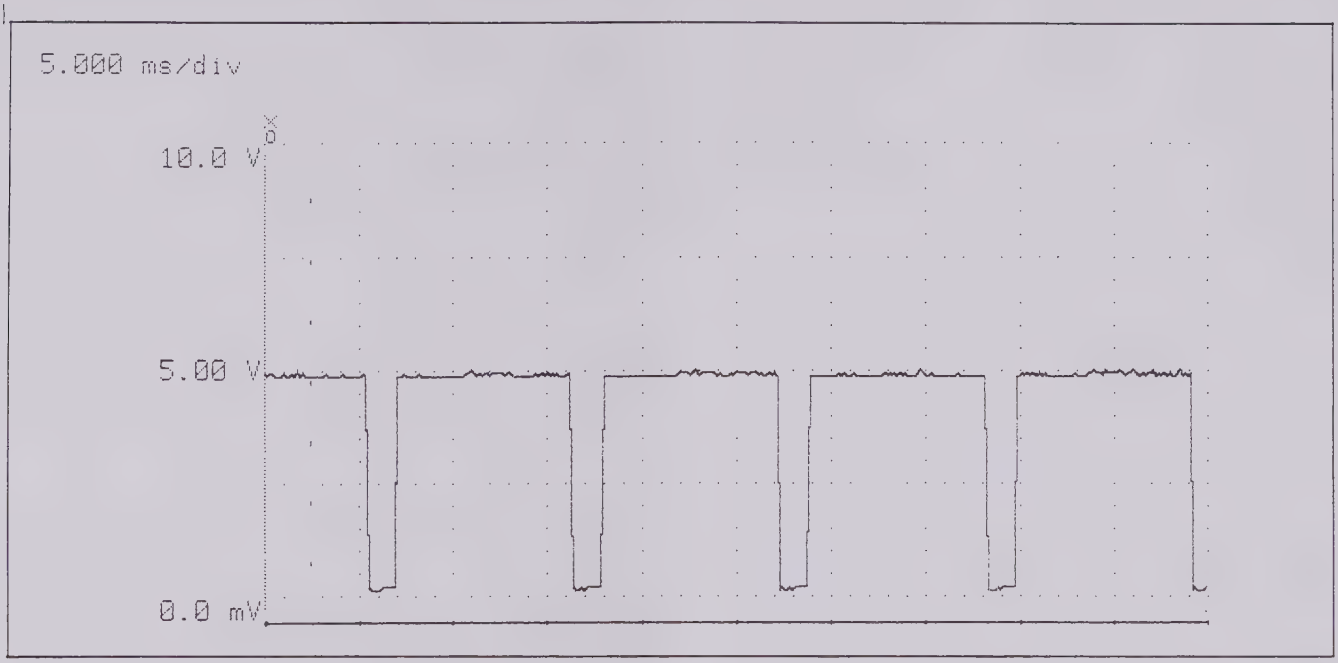
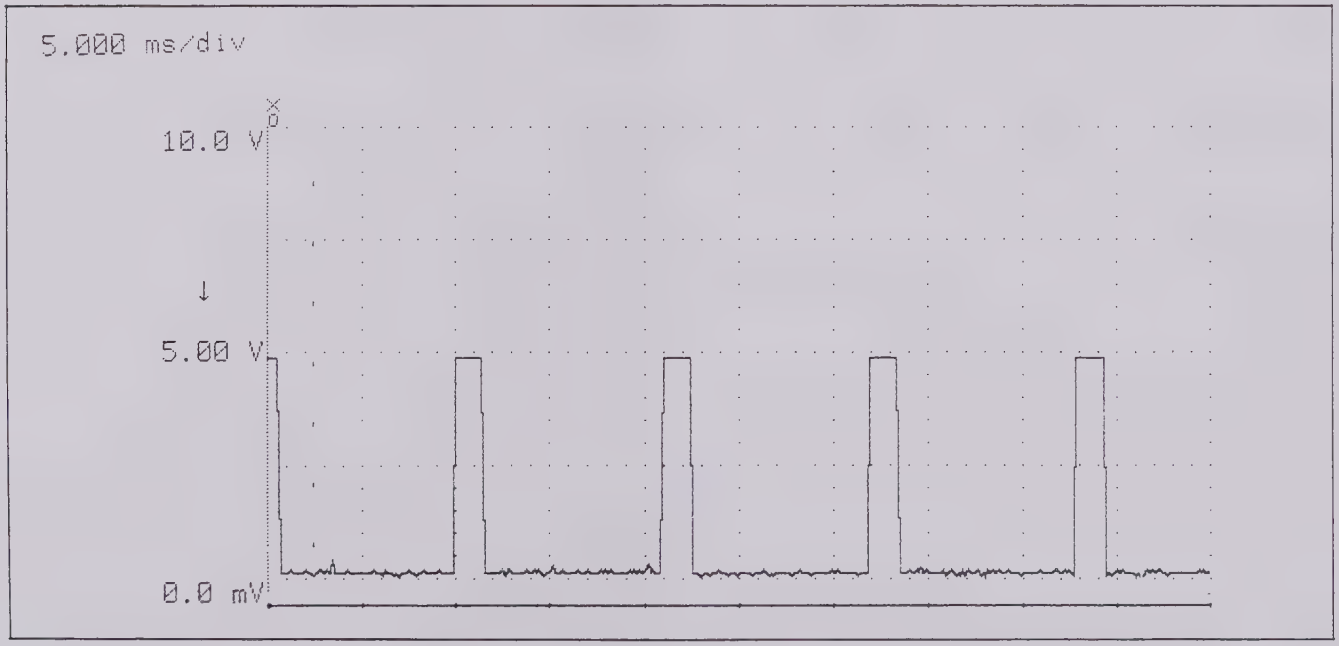


WAVEFORM 10



WAVEFORM 11



WAVEFORM 12

SECTION 9
Replaceable Parts

9.1 INTRODUCTION

This section contains replacement parts information, schematic diagrams, and component layout drawings for the Model 263 Calibrator/Source.

9.2 ELECTRICAL PARTS LISTS

Electrical parts for the Model 263 circuit boards are integrated with the component layout drawings and schematic diagrams for the respective circuit boards. Parts are listed alphabetically in order of circuit designation.

9.3 MECHANICAL PARTS

A miscellaneous mechanical parts list is located at the end of this section.

9.4 ORDERING INFORMATION

Keithley Instruments, Inc. maintains a complete inventory of all normal replacement parts. To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See the inside front cover of this manual for addresses.

When ordering parts, include the following:

1. Instrument model number.
2. Instrument serial number.
3. Part description.
4. Circuit designation, including schematic diagram and component layout numbers (if applicable).
5. Keithley part number.

9.5 FACTORY SERVICE

If the instrument or modules are to be returned to the factory for service, carefully pack them and include the following information:

1. Complete the service form at the back of this manual and return it with the instrument.
2. Advise as to the warranty status of the instrument (see the inside front cover of this manual for warranty information.
3. Write the following on the shipping label: ATTENTION REPAIR DEPARTMENT.

9.6 COMPONENT LOCATION DRAWINGS AND SCHEMATIC DIAGRAMS

Component location drawings and schematic diagrams for the various circuit boards can be found on the following pages arranged as follows:

Board	Component Layout Number	Schematic Diagram Number
Mother	263-100	263-106
Display	263-110	263-116
Analog	263-120	263-126

MODEL 263 DIGITAL BOARD, PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
C1	CAP,4700uF,-20+100%,16V,ALUM ELEC	C-313-4700
C2..C5	CAP,10uF,-20+100%,25V,ALUM ELEC	C-314-10
C21,C22	CAP,1uF,20%,50V,CERAMIC	C-237-1
C23,C24	CAP,22pF,10%,1000V,CERAMIC	C-64-22P
C25	CAP,.001uF,10%,100V,POLYPROPYLENE	C-306-.001
C27	CAP,22pF,20%,500V,CERAMIC	C-22-22P
C28,C29	CAP,1.2uF,10%,50V,POLYCARBONATE	C-335-1.2
C30	CAP,1uF,20%,50V,POLYESTER	C-350-1
C31	CAP,.047uF,10%,100V,POLYPROPYLENE	C-306-.047
C32	CAP,.22uF,10%,50V,METALLIZED POLYPRO.	C-269-.22
C33	CAP,2uF,10%,100V,POLYESTER	C-294-2
C34,C35	CAP,0.1uF,20%,100V,POLYESTER	C-305-.1
C36	CAP,.022uF,10%,100V,EPOXY	C-371-.022
C37	CAP,100pF,10%,1000V,CERAMIC	C-64-100P
C38,C39	CAP,680uF,-10+100%,35V,ELECTROLYTIC	C-309-680
C40	CAP,4700uF,-20+100%,16V,ALUM ELEC	C-313-4700
C41..C43	CAP,10uF,-20+100%,25v,ALUM ELEC	C-314-10
C44	CAP,220uF,-20+100%,25V,ALUM ELEC	C-314-220
C45	CAP,1000uF,-10+100%,35V,ELECTROLYTIC	C-309-1000
C46,C47	CAP,.1uF,20%,50v,CERAMIC	C-365-.1
C48	CAP,1000uF,-10+100%,35V,ELECTROLYTIC	C-309-1000
C49	CAP,100pF,10%,1000V,CERAMIC	C-64-100P
C50	CAP,1000uF,-10+100%,35V,ELECTROLYTIC	C-309-1000
C51	CAP,1uF,20%,50V,CERAMIC	C-237-1
C7	CAP,33pF,10%,1000V,CERAMIC	C-64-33P
C8	CAP,2200pF,10%,1000V,CERAMIC	C-64-2200P
C9..C20	CAP,.1uF,20%,50V,CERAMIC	C-365-.1
CR1,CR2	DIODE,BRIDGE,VM18	RF-52
CR3	DIODE,SILICON,IN4148 (DO-35)	RF-28
CR4..CR9	DIODE,SILICON,1N4006 (DO-41)	RF-38
F1	FUSE,.25A,250V,3AG,SLO-BLO	FU-17
F1(EUROPEAN)	FUSE,1/8A,250V,3AG,SLO-BLO	FU-20
J1	CONN,AC RECEPTACLE (LINE FILTER)	LF-4
J2	CONN,RIGHT ANGLE,24 PIN	CS-507
J8	SOCKET,24-PIN	SO-68
J9	CONN,FEMALE,24 PIN	CS-513
Q15	TRANS,N CHANNEL JFET,5432 (TO-92)	TG-198
Q2,Q3	TRANS,N CHANNEL MOSPOW FET,2N7000(TO-92)	TG-195
Q5..Q8	TRANS,MOSFET POWER,BUZ11 (TO-220)	TG-211
Q9..Q14	TRANS,P CHANNEL JFET,J270 (TO-92)	TG-166
R1	RES,10M,5%,1/4W,COMPOSITION OR FILM	R-76-10M
R10	RES,20K,.25%,1/8W,METAL FILM	R-351-20K

MODEL 263 DIGITAL BOARD, PARTS LIST (CONT.)

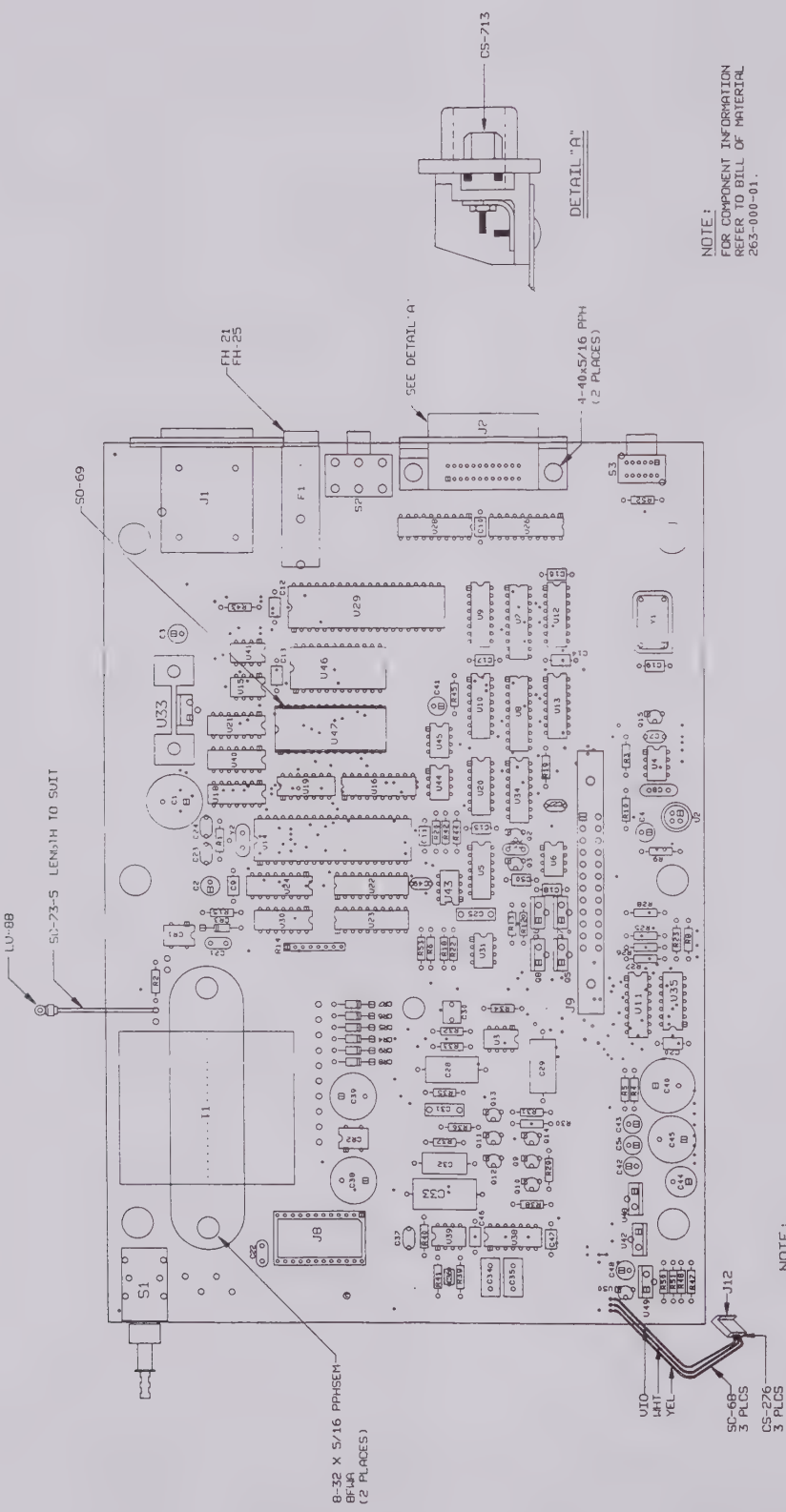
CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
R12,R13	RES,100,.1%,1/10W,METAL FILM	R-263-100
R14	RES NET,10K,2%,1.3W	TF-179-1
R15	RES,30K,5%,1/4W,COMPOSITION OR FILM	R-76-30K
R18	RES,680,5%,1/4W,COMPOSITION OR FILM	R-76-680
R19	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R2	RES,10M,5%,1/4W,COMPOSITION OR FILM	R-76-10M
R20	RES,560,5%,1/4W,COMPOSITION OR FILM	R-76-560
R22	RES,1.002K,.1%,1/10W,METAL FILM	R-263-1.002K
R23	RES,2K,5%,1/4W,COMPOSITION OR FILM	R-76-2K
R25..R31	RES,100K,5%,1/4W,COMPOSITION OR FILM	R-76-100K
R3	RES,10.7K,.25%,1/8W,METAL FILM	R-351-10.7K
R32,R33	RES,23.2K,1%,1/8W,METAL FILM	R-88-23.2K
R34	RES,40K,.25%,1/8W,METAL FILM	R-351-40K
R35	RES,160K,.25%,1/8W,METAL FILM	R-351-160K
R36	RES,400K,.25%,1/4W,METAL FILM	R-351-400K
R37	RES,44.44K,.25%,1/8W,METAL FILM	R-351-44.44K
R38	RES,4K,.25%,1/8W,METAL FILM	R-351-4K
R39	RES,39.2K,1%,1/8W,METAL FILM	R-88-39.2K
R4	RES,243,1%,1/8W,METAL FILM	R-88-243
R40	RES,20,5%,1/4W,COMPOSITION OR FILM	R-76-22
R41	RES,4.99K,1%,1/8W,METAL FILM	R-88-4.99K
R42	RES,1K,5%,1/4W,COMPOSITION OR FILM	R-76-1K
R43	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R44,R45	RES,5.1K,5%,1/4W,COMPOSITION OR FILM	R-76-5.1K
R47	RES,9.09K,1%,1/8W,METAL FILM	R-88-9.09K
R48	RES,511,1%,1/8W,METAL FILM	R-88-511
R5	RES,909,1%,1/8W,METAL FILM	R-88-909
R50	RES,499,1%,1/8W,METAL FILM	R-88-499
R51	RES,6.34K,1%,1/8W,METAL FILM	R-88-6.34K
R52	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R53	RES,6.8K,5%,1/4W,COMPOSITION OR FILM	R-76-6.8K
R6	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R8	RES,1K,5%,1/4W,COMPOSITION OR FILM	R-76-1K
R9	RES,2.43K,1%,1/8W,METAL FILM	R-88-2.43K
S1	SWITCH,PUSHBUTTON (6 POLE)	SW-466
S2	SWITCH,SLIDE (DPDT)	SW-318
S3	SWITCH,SLIDE (4PDT)	SW-465
T1	TRANSFORMER,JAPAN	TR-260
T1	TRANSFORMER	TR-256
U12,U13	IC,8 BIT BINARY COUNTER,74HC590	IC-531
U14	IC,CMOS 8 BIT MICROPROCESSOR,146805E2	LSI-60
U15	IC,16X16 BIT SERIAL RAM,X2443P	IC-353
U16	IC,OCTAL 3-STATE NONINV D-TYPE,74HC573	IC-458
U18	IC,QUAD 2-INPUT NAND,74HC00	IC-351
U19	IC,QUAD INPUT NAND,74HC132	IC-513

MODEL 263 DIGITAL BOARD, PARTS LIST (CONT.)

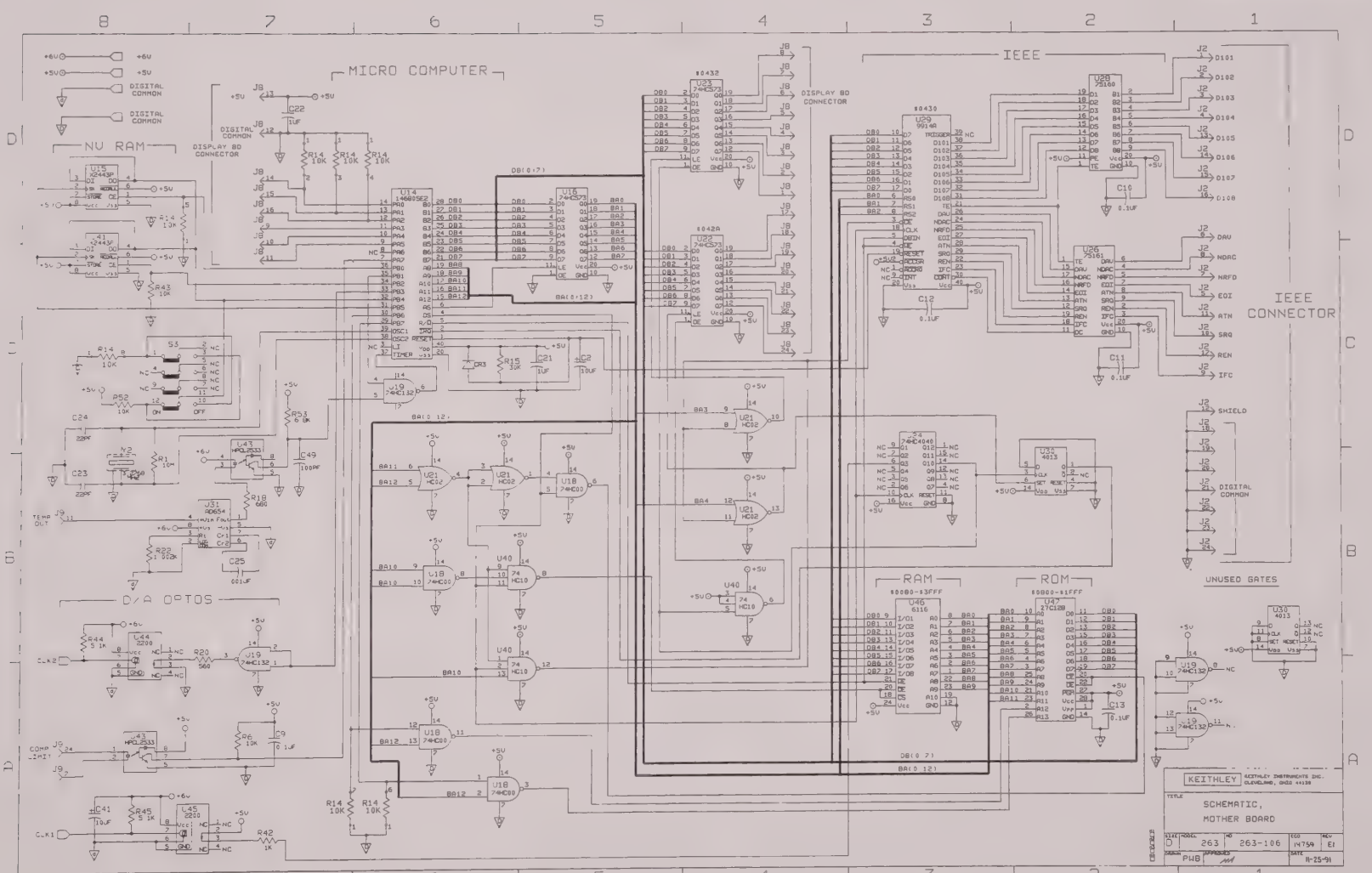
CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
U2	IC,PRECISION REFERENCE,LM399	IC-527
U20	IC,QUAD 2-INPUT NAND,74HC00	IC-351
U21	IC,QUAD 2-INPUT OR,74HC02	IC-412
U22,U23	IC,OCTAL 3-STAGE NONINV D-TYPE,74HC573	IC-458
U24	IC,12 STAGE BINARY COUNTER,74HC4040	IC-407
U26	IC,OCTAL INTERFACE BUS TRANSCEIVER,75161	IC-299
U28	IC,OCTAL INTERFACE BUS,75160	IC-298
U29	IC,GPIB ADAPTER,9914A	LSI-49
U3	IC,18V OP-AMP,TL061	IC-227
U30	IC,DUAL D TYPE FLIP FLOP,4013	IC-103
U31	IC,MONO VOLT-TO-FREQ CONVERTER,AD654	IC-539
U33	IC and Heat Sink, +5V Regulator, 7805	32469-2
U34	IC,DUAL BINARY UP COUNTER,MC14520B	IC-324
U35	IC,LOW POWER OFFSET VOLT QUAD COMP,399	IC-219
U38	IC,OP-AMP,LT1052CN	IC-575
U39	IC,SINGLE & DUAL LOW NOISE OP-AMP,5534	IC-540
U4	IC,18V OP-AMP,LM308AW	IC-203
U40	IC,TRIPLE 3 INPUT NAND,74HC10	IC-341
U41	IC,16X16 BIT SERIAL RAM,X2443P	IC-353
U42	IC,VOLTAGE REGULATOR,LM337MP	IC-309
U43	IC,DUAL LOGIC INTERFACE OPTOCOUPLER	IC-332
U44,U45	IC,LOW INPUT CURRENT OPTO,HCPL-2200	IC-411
U46	IC,2048 WORDX8 BIT HI SP ST CMOS,6116	LSI-58
U47	PROGRAM	263-800-**
U48	IC,VOLTAGE REGULATOR,LM317T	IC-317
U49	IC,VOLTAGE REGULATOR,LM317MP	IC-308
U5	IC,DUAL D-TYPE FLIP-FLOP,74HC74	IC-337
U50	IC,VOLTAGE REGULATOR,LM320LZ-5	IC-395
U6	IC,DUAL POWER MOSFET DRIVER,TSC426	IC-437
U7,U8	IC,8 BIT MAGNITUDE COMPARATOR,74HC684	IC-478
U9..U11	IC,8 STAGE SHIFT/STORE REGISTER,4094	IC-251
Y1	CRYSTAL,10MHZ	CR-28-1
Y2	CRYSTAL,3.2768MHZ	CR-21

**Order same software as presently installed. For example, if the software revision level is A1, then order 263-800-A1.

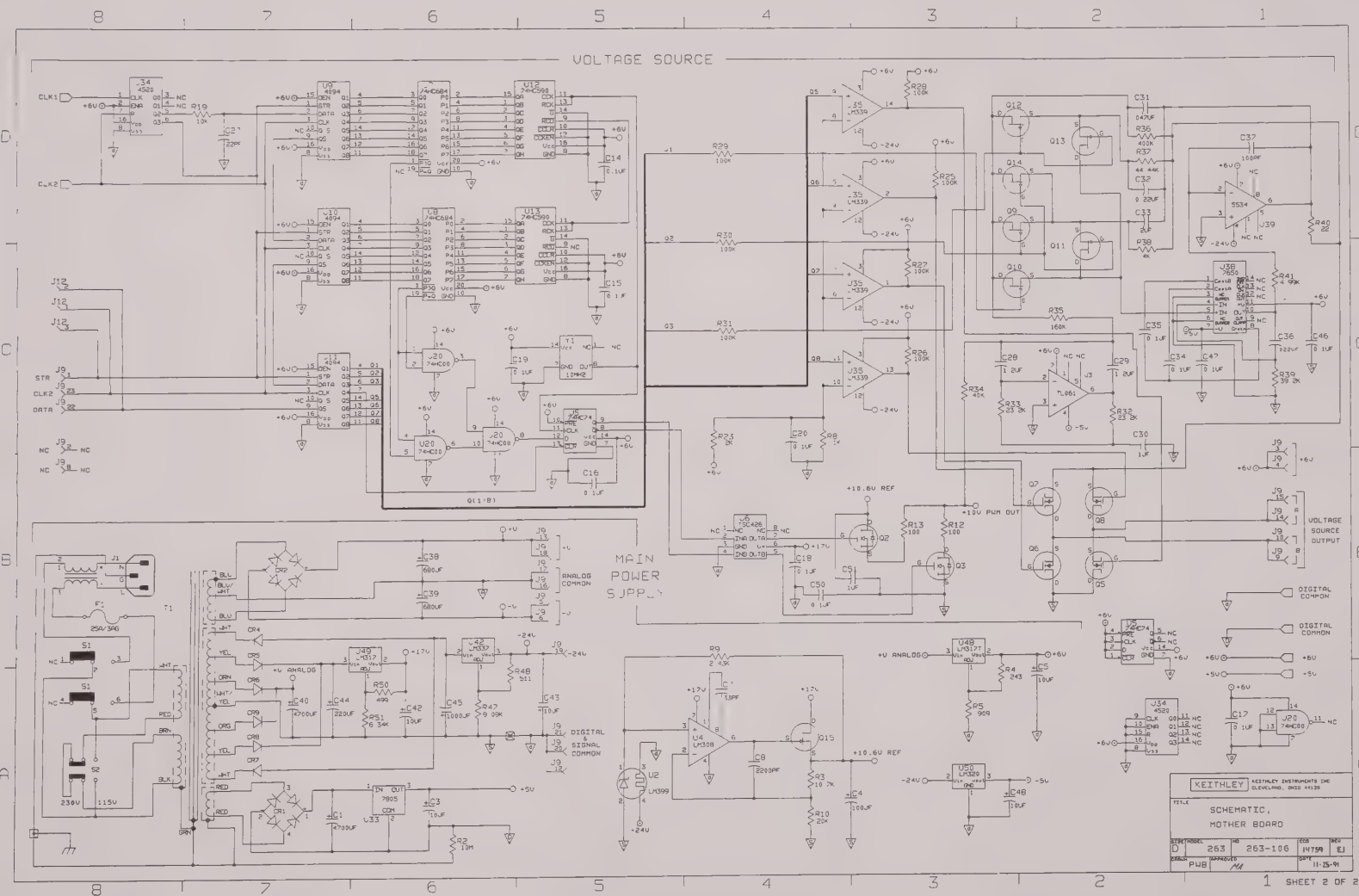
LTR.	ECO NO.	REVISION	ENG.	DATE
C	12161	RELEASED		6/12/87
D	12295	REVISED	S2	8/10/87
D1	12317	REVISED	S2	9/24/87
D2	12473	REVISED	S2	12/29/87
E	13761	CHG'D ARTWORK REV FROM D TO E ADDED CAP HOLDER, WAS #73x1.4MM. ADDED CAP SPOT, WAS #73x1.4MM.	S2	3/21/90
E1	14029		S2	4/24/90
E2	14617	CHG'D CS-378 TO CS-713		6/19/91



Mother Board, Component Location Drawing, (Dwg. No. 263-100)



Mother Board, Schematic Diagram, (Dwg. No. 263-106) (Page 1 of 2)

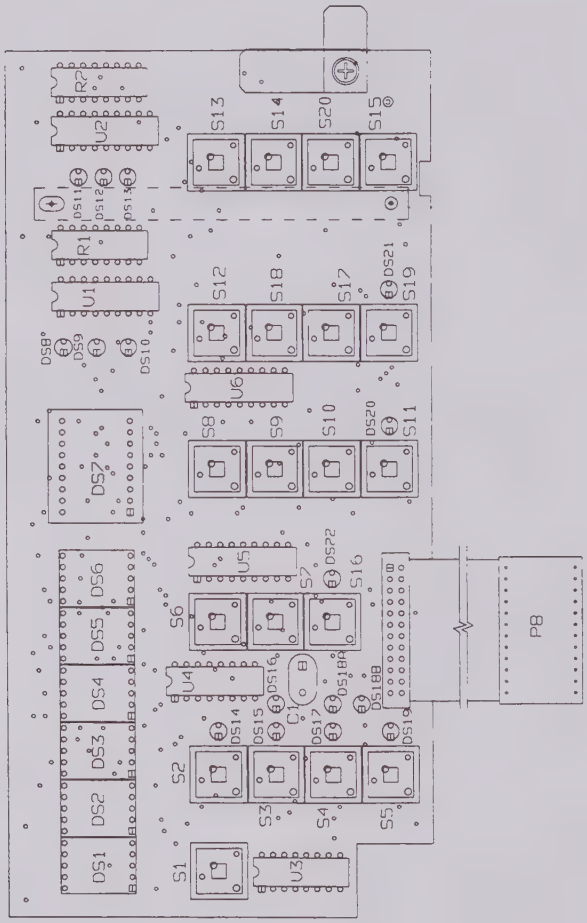


Mother Board, Schematic Diagram, (Dwg. No. 263-106) (Page 2 of 2)

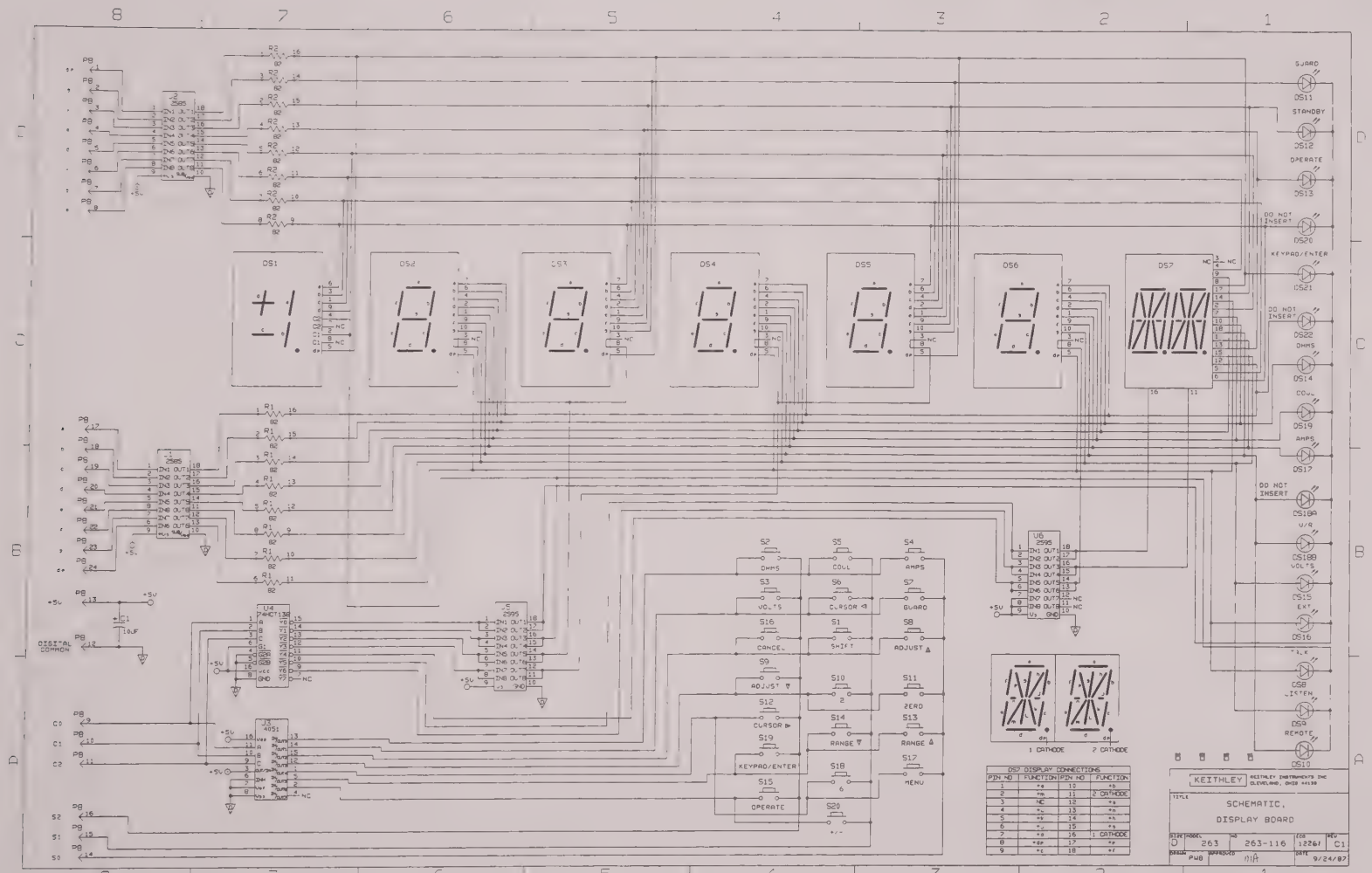
MODEL 263 DISPLAY BOARD PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
C1	CAP,10UF,20%,20V,TANTALUM	C-179-10
DS1, DS11...DS17	DISPLAY,DIGITAL	DD-31
DS18,DS19,DS21	PILOT LIGHT,YEL,LED	PL-72
DS2..DS6	DISPLAY,DIGITAL	DD-30
DS7	DISPLAY,DIGITAL (DOUBLE DIGIT)	DD-39
DS8..DS10	PILOT LIGHT,RED,LED	PL-71
P8	CABLE ASSEMBLY,24 CONDUCTOR	CA-30-4
R1,R2	RES NET,82,5%,.25W	TF-141
S1..S20	SWITCH,MOMENTARY	SW-435
U1,U2	IC,8 CHANNEL SOURCE DRIVER,UDN2585	IC-405
U3	IC,ANALOG MULTIPLEXER,4051	IC-277
U4	IC,3-8 LINE DECODER/DEMULTI,74HCT138	IC-398
U5,U6	IC,8 CHANNEL CURRENT SINK DRIVER,UDN2595	IC-406

LTR.	ECO NO.	REVISION	ENG.	DATE
C	12161	RELEASED	SZ	6-12-87
C1	19521	REPLACED MK-22-3 WITH MK-22-1 ADDED PL-21		2-23-91



Display Board, Component Location Drawing, (Dwg. No. 263-110)



Display Board, Schematic Diagram, (Dwg. No. 263-116)

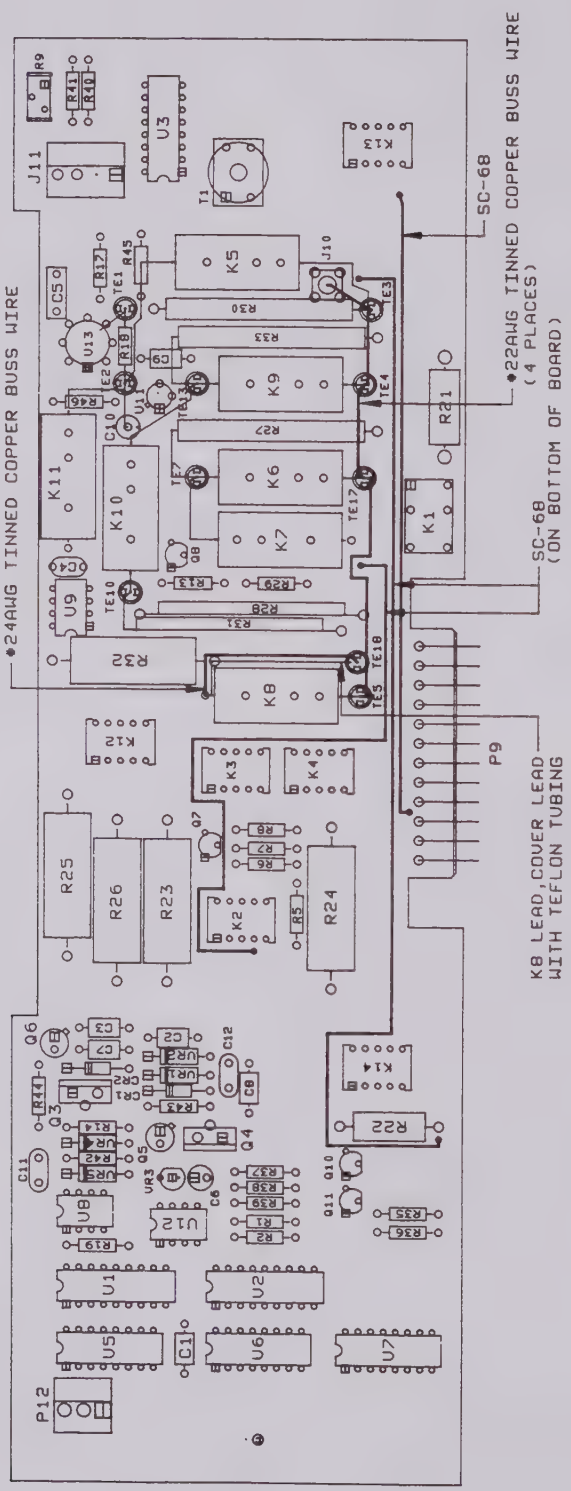
MODEL 263 ANALOG BOARD, PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
C1..C3	CAP,.1uF,20%,50V,CERAMIC	C-365-.1
C10	CAP,10PF,5%,500V,POLYSTYRENE	C-138-10P
C11,C12	CAP,1uF,20%,50V,CERAMIC	C-237-1
C4	CAP,33pF,10%,1000V,CERAMIC	C-64-33P
C5	CAP,.01uF,20%,100V,POLYESTER	C-305-.01
C6	CAP,4.7uF,-20+100%,25V,AL ELEC	C-314-4.7
C7..C9	CAP,.1uF,20%,50V,CERAMIC	C-365-.1
CR1,CR2	DIODE,SILICON,IN4006 (DO-11)	RF-38
J10	CONN,SMB,MALE,P.C. MOUNT	CS-545
J11	CONNECTOR, MODIFIED	A263-311
K1	RELAY (DPST)	RL-114
K12..K14	RELAY (DPDT)	RL-166
K2..K4	RELAY (DPDT)	RL-166
K5..K11	RELAY (SPST)	RL-70
P12	CONN,MALE,3 PIN	CS-288-3
Q10,Q11	TRANS,PNP SILICON,2N3906 (TO-92)	TG-84
Q3	TRANS,NPN DARLINGTON,SGS/TIP122 (TO-220)	TG-191
Q4	TRANS,PNP DARLINGTON,SGS/TIP127 (TO-220)	TG-190
Q5,Q6	TRANS,CURRENT REGULATOR,CR120	TG-159
Q7,Q8	TRANS,P CHANNEL JFET,J270 (TO-92)	TG-166
R1	RES,470,5%,1/4W,COMPOSITION OR FILM	R-76-470
R13	RES,47,5%,1/4W,COMPOSITION OR FILM	R-76-47
R14	RES,2.7K,5%,1/4W,COMPOSITION OR FILM	R-76-2.7K
R17	RES,10K,1%,1/8W,METAL FILM	R-88-10K
R18	RES,10M,5%,1/4W,COMPOSITION OR FILM	R-76-10M
R19	RES,1.2K,5%,1/4W,COMPOSITION OR FILM	R-76-1.2K
R2	RES,560,5%,1/4W,COMPOSITION OR FILM	R-76-560
R21	RES,1K,10%,2W,1000V,FIXED WIREWOUND	R-330-1K
R22	RES,100K,10%,1W,COMPOSITION	R-2-100K
R23	RES,10.101K,.75W,WIREWOUND	R-353-10.101K
R24	RES,111.11K,.75W,WIREWOUND	R-353-111.11K
R25,R26	RES,2.002K,.75W,WIREWOUND	R-353-2.002K
R27	RES,1G,2%,1.5W,HY MEG	R-289-1G
R28	RES,9.99M,.1%,METAL FILM OR OXIDE FILM	R-294-9.99M
R29	RES,110K,.1%,1/10W,METAL FILM	R-263-110K
R30	RES,100G,2%,1.5W,HY MEG	R-289-100G
R31	RES,100M,.1%,.75W,FILM	R-362-100M
R32	RES,1M,.75W,WIREWOUND	R-353-1M
R33	RES,11.1G,2%,1.5W,HY MEG	R-289-11.1G
R35,R36	RES,33K,5%,1/4W,COMPOSITION OR FILM	R-76-33K
R37	RES,4.99K,.1%,1/10W,METAL FILM	R-263-4.99K

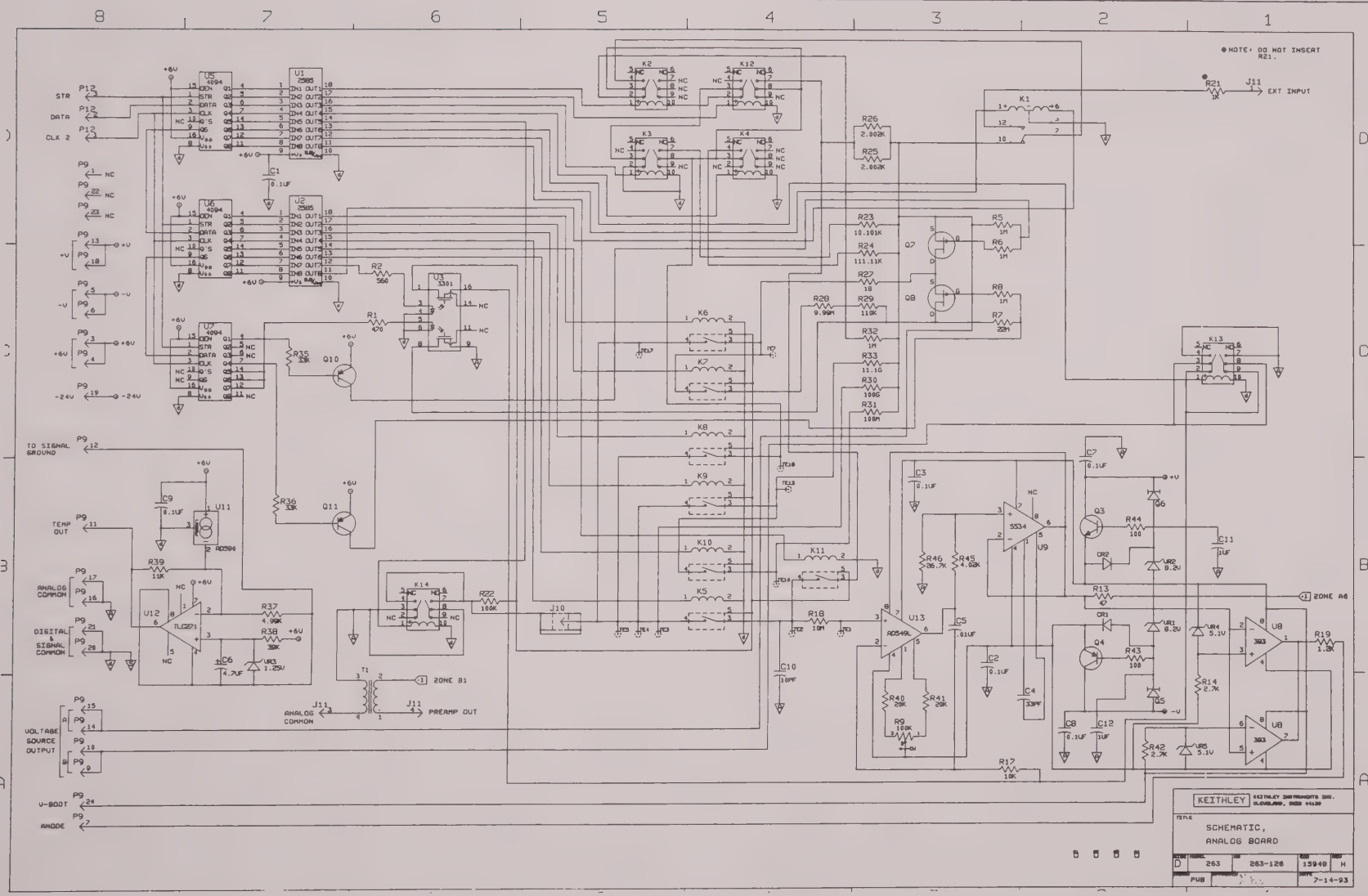
MODEL 263 ANALOG BOARD, PARTS LIST

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
R38	RES,39K,5%,1/4W,COMPOSITION OR FILM	R-76-39K
R39	RES,11K,.1%,1/10W,METAL FILM	R-263-11K
R40,R41	RES,20K,1%,1/8W,METAL FILM	R-88-20K
R42	RES,2.7K,5%,1/4W,COMPOSITION OR FILM	R-76-2.7K
R43,R44	RES,100K,5%,1/4W,COMPOSITION OR FILM	R-76-100K
R45	RES,4.02K,1%.1/8W,METAL FILM	R-88-4.02K
R46	RES,18.2K,1%.1/8W.METAL FILM	R-88-18.2K
R5,R6	RES,1M,5%,1/4W,COMPOSITION OR FILM	R-76-1M
R7	RES,22M,5%,1/4W,COMPOSITION OR FILM	R-76-22M
R8	RES,1M,5%,1/4W,COMPOSITION OR FILM	R-76-1M
R9	POT,100K,10%,.5W,NON-WIREWOUND	RP-111-100K
T1	TRANSFORMER	TR-214
TE1...TE5 TE10,TE13,TE17 TE18 TE7	TERMINAL (TEFLON)	TE-97-1
U1	IC,8 CHANNEL SOURCE DRIVER,UDN2585	IC-405
U11	IC,TEMPERATURE TRANSDUCER,AD590KH	IC-447
U12	IC,PROGRAMMABLE OP-AMP,TLC271	IC-347
U13	IC,OP-AMP,OPA128	IC-542
U2	IC,8 CHANNEL SOURCE DRIVER,UDN2585	IC-405
U3	IC,PHOTOVOLTAIC RELAY,PVR3301	IC-525
U5..U7	IC,8 STAGE SHIFT/STORE REGISTER,4094	IC-251
U8	IC,DUAL VOLTAGE COMPARATOR,LM393	IC-343
U9	IC,SINGLE & DUAL LOW NOISE OP-AMP,5534	IC-540
VR1,VR2	DIODE,ZENER 8.5V, 1N4101	DZ-82
VR3	DIODE,1.25V,	DZ-62
VR4,VR5	DIODE,ZENER 6.44V, 1N4577AGED	DZ-58

LTR.	ECO NO.	REVISION	ENG.	DATE
C	12161	RELEASED		6-9-87
E	12317	REVISED		8-21-87
F	12426	REVISED	SZ	2-22-88
F1	13778	REVISED VR3'S PACKAGE	SZ	1-5-90
G	13868	ARTWORK WAS REV F. RELOCATED T1	AS	9-20-90
H	15949	ARTWORK WAS REV G. CHG'D K2-K4 FROM RL-117 TO RL-103. ALSO CHG'D K12-K14 FROM RL-104 TO RL-102.	SZ	7-27-93
H1	16115	REVISED K2-K4 AND K12-K14.		12-1-93



Analog Board, Component Location Drawing, (Dwg. No. 263-120)



Analog Board, Schematic Diagram, (Dwg. No. 263-126)

MODEL 263 MISCELLANEOUS PARTS, PARTS LIST

QUANTITY	DESCRIPTION	KEITHLEY PART NO.
	Bottom Cover Assembly	
1	Bottom Cover	617-318
1	Bottom Cover Shield	617-321
1	Insulator (installed on bottom cover shield)	617-310
1	Shield (installed on insulator)	617-305
1	Tilt Bail	30544
1	Dress Panel (for tilt bail)	30587
1	Drive Pin (for tilt bail)	FA-143-1
4	Foot	FE-14
	Top Cover Assembly	
1	Top Cover	30540
1	Shield	617-322
	Front Panel Assembly	
1	Front Panel (includes display window)	617-301
1	Overlay	263-302
1	Shield	263-305
	Rear Panel Assembly	
1	Rear Panel	263-303
	OUTPUT Cable Assembly	
1	Triax Connector	CS-440
1	Cable Assembly (includes SMB connector P10)	CA-59-1
	Connector (P11) Assembly	
1	Housing	CS-276-4
3	Contact	CS-276
3	Lug	LU-99-1
1	Binding Post (Black)	BP-11-0
2	Binding Post (Red)	BP-11-2
1	Binding Post (Chassis Ground)	BP-15
1	Shorting Link	BP-6
1	IEEE Hardware Kit (for IEEE connector)	CS-378
2	Grounding Clip	775-306
1	Card Guide	CS-595-1
1	Triax Protection Cap	CAP-18
1	Line Cord	CO-7
1	Triax Cable	Model 7024-3
	Mother Board	
1	Shield	263-106
1	Grounding Clip	197-314
1	Fuse Carrier (3AG)	FH-25
1	Fuse Holder Body	FH-21
1	Pushbutton (Red)	29465-3
1	Socket (for U47)	SO-69
6	Collar	30545

MODEL 263 MISCELLANEOUS PARTS, PARTS LIST (CONT.)

QUANTITY	DESCRIPTION	KEITHLEY PART NO.
	Analog Board	
1	Top Shield	263-308
1	Bottom Shield	263-309
1	Grommet	GR-46
	Display Board	
1	Card Guide	CS-595-1
1	Ground Clip	617-320
1	Pushbutton (SHIFT)	228-317-4
14	Pushbutton (CONTROL group)	228-317-6
1	Pushbutton (OPERATE)	228-317-7
4	Pushbutton (FUNCTION group)	228-317-5

APPENDIX A

Device-Dependent Command Summary

Mode	Command	Description	Paragraph
Execute	X	Execute other device-dependent commands	4.7.15
Function	F0	Ohms	4.7.4
	F1	Amps	
	F2	Volts	
	F3	Coulombs	
	F4	V/R Amps	
	F5	External Volts	
	F6	Ladder	
	F7	V/R Coulombs	
Range		**Ohms** **Amps** **Volts** **Coul** **Ladder**	4.7.11
	R0	Auto On Auto On Auto On Auto On Auto On	
	R1	1 kΩ 2 pA 200mV 20pC 1ML	
	R2	10 kΩ 20 pA 2 V 200pC 10ML	
	R3	100 kΩ 200 pA 20 V 2nC 100ML	
	R4	1MΩ 2 nA 20 V 20nC 1GL	
	R5	10MΩ 20 nA 20 V 200nC 10GL	
	R6	100MΩ 200 nA 20 V 2μC 100GL	
	R7	1GΩ 2 μA 20 V 20μC 100GL	
	R8	10GΩ 20 μA 20 V 200μC 100GL	
	R9	100GΩ 200 μA 20 V 200μC 100GL	
	R10	100GΩ 2mA 20 V 200μC 100GL	
	R11	100GΩ 20mA 20 V 200μC 100GL	
	R12	Auto Off Auto Off Auto Off Auto Off Auto Off	
Zero	Z0	Zero off	4.7.17
	Z1	Zero on	
Temperature Compensation	C0	Temperature compensation off	4.7.3
	C1	Temperature compensation on	
Guard	W0	Guard Off	4.7.14
	W1	Guard On	
Self-Test	J0	Perform self-test	4.7.6
Status	U0	Send machine status word	4.7.12
	U1	Send error conditions	
	U2	Send data conditions	
EOI	K0	Enable EOI	4.7.7
	K1	Disable EOI	
SRQ	M0	Disable	4.7.9
	M2	Charge done	
	M16	Ready	
	M32	Error	
Calibration Value	An	Calibrate using value	4.7.2
Calibration Value	Ln	Calibrate temperature cal points	4.7.8

Mode	Command	Description	Paragraph
Output Value	Vn	Program output using value	4.7.13
Prefix	G0 G1	Reading with prefix Reading without prefix	4.7.15
Operate	O0 O1	Standby Operate	4.7.10
Terminator	Y0 Y1 Y2 Y3 Y4	CR LF LF CR CR LF None	4.7.16

APPENDIX B

Interface Function Codes

The interface function codes, which are part of the IEEE-488-1978 standards, define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual. The interface function codes for the Model 263 are listed in Table B-1. These codes are also listed for convenience on the rear panel adjacent to the IEEE-488 connector. The codes define Model 263 capabilities as follows:

SH (Source Handshake Function)—SH1 defines the ability of the instrument to initiate the transfer of message/data over the data bus.

AH (Acceptor Handshake Function)—AH1 defines the ability of the instrument to guarantee proper reception of message/data transmitted over the data bus.

T (Talker Function)—The ability of the instrument to send data over the bus to other devices is provided by the T function. Instrument talker capabilities (T6) exist only after the instrument has been addressed to talk.

L (Listener Function)—The ability for the instrument to receive device-dependent data over the bus from other devices is provided by the L function. Listener capabilities (L4) of the instrument exist only after it has been addressed to listen.

SR (Service Request Function)—SR1 defines the ability of the instrument to request service from the controller.

RL (Remote-Local Function)—RL0 defines the ability of the instrument to be placed in the remote or local modes.

PP (Parallel Poll Function)—The instrument does not have parallel polling capabilities (PP0).

DC (Device Clear Function)—DC1 defines the ability of the instrument to be cleared (initialized).

DT (Device Trigger Function)—The ability for the instrument to have its readings triggered is provided DT1.

C (Controller Function)—The instrument does not have controller capabilities (C0).

TE (Extended Talker Function)—The instrument does not have extended talker capabilities (TE0).

LE (Extended Listener Function)—The instrument does not have extended listener capabilities (LE0).

E (Bus Driver Type)—The instrument has open-collector bus drivers (E1).

Table B-1. Model 263 Interface Function Codes

Code	Interface Function
SH1	Source Handshake capability
AH1	Acceptor Handshake capability
T6	Talker (basic talker, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service Request capability
RL0	Some Remote/Local capability
PP0	No Parallel Poll capability
DC1	Device Clear capability
DT1	Device Trigger capability
L0	No Controller capability
E1	Open Collector Bus Drivers
TE0	No Extended Talker capabilities
LE0	No Extended Listener capabilities

APPENDIX C

ASCII Character Codes and IEEE-488 Multiline Interface Command Messages

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
0	00	NUL	
1	01	SOH	GTL
2	02	STX	
3	03	ETX	
4	04	EOT	SDC
5	05	ENQ	PPC
6	06	ACK	
7	07	BEL	
8	08	BS	GET
9	09	HT	TCT
10	0A	LF	
11	0B	VT	
12	0C	FF	
13	0D	CR	
14	0E	SO	
15	0F	SI	
16	10	DLE	
17	11	DC1	LLO
18	12	DC2	
19	13	DC3	
20	14	DC4	DCL
21	15	NAK	PPU
22	16	SYN	
23	17	ETB	
24	18	CAN	SPE
25	19	EM	SPD
26	1A	SUB	
27	1B	ESC	
28	1C	FS	
29	1D	GS	
30	1E	RS	
31	1F	US	

* Message sent or received with ATN true.

ASCII CHARACTER CODES AND IEEE-488 MULTILINE INTERFACE COMMAND MESSAGES

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
32	20	SP	MLA 0
33	21	!	MLA 1
34	22	"	MLA 2
35	23	#	MLA 3
36	24	$	MLA 4
37	25	%	MLA 5
38	26	&	MLA 6
39	27	'	MLA 7
40	28	(	MLA 8
41	29	)	MLA 9
42	2A	*	MLA 10
43	2B	+	MLA 11
44	2C	,	MLA 12
45	2D	–	MLA 13
46	2E	.	MLA 14
47	2F	/	MLA 15
48	30	0	MLA 16
49	31	1	MLA 17
50	32	2	MLA 18
51	33	3	MLA 19
52	34	4	MLA 20
53	35	5	MLA 21
54	36	6	MLA 22
55	37	7	MLA 23
56	38	8	MLA 24
57	39	9	MLA 25
58	3A	:	MLA 26
59	3B	;	MLA 27
60	3C	<	MLA 28
61	3D	=	MLA 29
62	3E	>	MLA 30
63	3F	?	UNL

* Message sent or received with ATN true. Numbers shown represent primary address resulting in MLA (My Listen Address).

ASCII CHARACTER CODES AND IEEE-488 MULTILINE INTERFACE COMMAND MESSAGES

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
64	40	@	MTA 0
65	41	A	MTA 1
66	42	B	MTA 2
67	43	C	MTA 3
68	44	D	MTA 4
69	45	E	MTA 5
70	46	F	MTA 6
71	47	G	MTA 7
72	48	H	MTA 8
73	49	I	MTA 9
74	4A	J	MTA 10
75	4B	K	MTA 11
76	4C	L	MTA 12
77	4D	M	MTA 13
78	4E	N	MTA 14
79	4F	O	MTA 15
80	50	P	MTA 16
81	51	Q	MTA 17
82	52	R	MTA 18
83	53	S	MTA 19
84	54	T	MTA 20
85	55	U	MTA 21
86	56	V	MTA 22
87	57	W	MTA 23
88	58	X	MTA 24
89	59	Y	MTA 25
90	5A	Z	MTA 26
91	5B	[	MTA 27
92	5C	\	MTA 28
93	5D	]	MTA 29
94	5E	∩	MTA 30
95	5F	—	UNT

* Message sent or received with ATN true. Numbers shown are primary address resulting in MTA (My Talk Address).

ASCII CHARACTER CODES AND IEEE-488 MULTILINE INTERFACE COMMAND MESSAGES

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
96	60	∩	MSA 0,PPE
97	61	a	MSA 1,PPE
98	62	b	MSA 2,PPE
99	63	c	MSA 3,PPE
100	64	d	MSA 4,PPE
101	65	e	MSA 5,PPE
102	66	f	MSA 6,PPE
103	67	g	MSA 7,PPE
104	68	h	MSA 8,PPE
105	69	i	MSA 9,PPE
106	6A	j	MSA 10,PPE
107	6B	k	MSA 11,PPE
108	6C	l	MSA 12,PPE
109	6D	m	MSA 13,PPE
110	6E	n	MSA 14,PPE
111	6F	o	MSA 15,PPE
112	70	p	MSA 16,PPD
113	71	q	MSA 17,PPD
114	72	r	MSA 18,PPD
115	73	s	MSA 19,PPD
116	74	t	MSA 20,PPD
117	75	u	MSA 21,PPD
118	76	v	MSA 22,PPD
119	77	w	MSA 23,PPD
120	78	x	MSA 24,PPD
121	79	y	MSA 25,PPD
122	7A	z	MSA 26,PPD
123	7B	{	MSA 27,PPD
124	7C	|	MSA 28,PPD
125	7D	}	MSA 29,PPD
126	7E	~	MSA 30,PPD
127	7F	DEL	

*Message send or received with ATN true. Numbers represent secondary address values resulting in MSA (My Secondary Address).

APPENDIX D

IBM PC/AT and CEC PC < >488 Interface Programming

INTRODUCTION

This appendix contains general programming information needed to control the Model 263 with the IBM PC/XT personal computer via the Capital Equipment Corporation PC< >488 interface. Refer to the CEC PC<488 Programming and Reference Manual for complete information.

INITIALIZING THE SYSTEM

The first step in any program is to initialize the system using the INITIALIZE routine. This routine sets the IEEE-488 bus primary address of the PC< >488, specifies the type of controller to be used, and sends an interface clear (IFC) to the other devices on the bus.

After booting up the IBM using DOS and entering BASICA, the following statements can be used at the start of any program to properly initialize the system:

Program	Comments
10 DEF SEG=&HC400	' Memory address.
20 INITIALIZE=0	' Offset address of routine.
30 MY.ADDRESS%=21	' Set PC< >488 address.
40 CONTROLLER%=0	' Set for system control.
50 CALL INITIALIZE(MY.ADDRESS%, CONTROLLER%)	' Execute INITIALIZE routine.

Line 30 sets the address of the PC< >488 to 21, however, any other valid address could be used as long as it does not conflict with the address of any other device on the bus.

INTERFACE BASIC PROGRAMMING STATEMENTS

This section covers the PC< >488 statements that are essential to Model 263 operation. A partial list of programming statements is contained in Table C-1. The IBM BASIC CALL statement is used to execute the desired action. Before a CALL routine can be used, BASIC needs to know the offset address of that routine. In the table, the first statement of each programming sequence defines the offset address of the CALL routine.

EXAMPLE PROGRAM

The following program sends a command string to the Model 263 from an IBM PC or AT computer and displays the instrument reading string on the CRT. The computer must be equipped with the CEC Interface and the DOS 2.00 (or later revisions) operating system.

DIRECTIONS

1. Using the front panel program feature, set the primary address of the Model 263 to 8.
2. With the power off, connect the Model 263 to the IEEE-488 interface installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into the IBM interpretive BASIC language.
4. Enter the lines below using the return key after each line.
5. Run the program and type in the desired command string. For example, to place the instrument in the current function and 200μA range, type in F1R9X and press the return key.
7. The instrument reading string will then appear on the display.

PROGRAM	COMMENTS
`10 DEF SEG=&HC400`	' Memory address.
`20 INITIALIZE=0`	' Lines 10-50...
`30 SEND=9: ENTER=21`	' Routine addresses.
`40 MY.ADDRESS%=21`	' PC < > 488 address.
`50 INST.ADDRESS%=8`	' 263 address.
`60 CONTROLLER%=0`	' System controller.
`70 CALL INITIALIZE (MY.ADDRESS%,CONTROLLER%)`	' Initialize system.
`80 INPUT ''ENTER COMMAND STRING'';CMD$`	' Prompt for string.
`90 CALL SEND (INST.ADDRESS%,CMD$,STATUS%)`	' Send command string.
`100 READING$=SPACE$(16)`	' Make room for data.
`110 CALL ENTER (READING$,LENGTH%,INST.ADDRESS%, STATUS%)`	' Get reading from 263.
`120 PRINT READING$`	' Display reading.
`130 GOTO 80`	' Repeat.
`140 END`	

NOTE: For conversion to numeric variable, make the following changes:

```
120 READING=VAL(MID$(READING$,5,14))
125 PRINT READING
```

Table D-1. BASIC Statements Necessary to Send Bus Commands

Action	PC< >488 Statements
Transmit command string (CMD$) to device 8.	SEND=9 ADDRESS%=8 CALL SEND(ADDRESS%,CMD$,STATUS%)
Obtain string from device 8.	ENTER=21 ADDRESS%=8: READING$=SPACE$(16) CALL ENTER(READING$,LENGTH%, ADDRESS%,STATUS%)
Send GTL to device 8.	TRANSMIT=3 CMD$=''LISTEN 8 GTL'' CALL TRANSMIT(CMD$,STATUS%)
Send SDC to device 8.	TRANSMIT=3 CMD$=''LISTEN 8 SDC'' CALL TRANSMIT(CMD$,STATUS%)
Send DCL to all devices.	TRANSMIT=3 CMD$=''LISTEN 8 DCL'' CALL TRANSMIT(CMD$,STATUS%)
Send remote enable.	TRANSMIT=3 CMD$=''REN LISTEN 8'' CALL TRANSMIT(CMD$,STATUS%)
Serial poll device 8.	SPOLL=12 CALL SPOLL%(ADDRESS%,POLL%, STATUS%)

APPENDIX E

Controller Programs

The following programs have been supplied as a simple aid to the user and are not intended to suit specific needs. Each program allows you send a device-dependent command string to the instrument and obtain and display an instrument reading string.

Programs for the following controllers are included:

- IBM PC or AT (with Capital Equipment Corporation PC < > 488 Interface).
- IBM PC or AT (with National GPIB PC Interface)
- Apple II (equipped with the Apple II IEEE-488 Interface)
- Hewlett-Packard Model 85
- Hewlett-Packard Series 300 and Model 9816
- Hewlett-Packard Model 9825A
- DEC LSI 11

IBM PC OR AT
(CAPITAL EQUIPMENT CORPORATION PC < > 488 INTERFACE)

The following program sends a command string to the Model 263 from an IBM PC or AT computer and displays the instrument reading string on the CRT. The computer must be equipped with the CEC Interface and the DOS 2.00 (or later revisions) operating system.

DIRECTIONS

1. Using the front panel program feature, set the primary address of the Model 263 to 8.
2. With the power off, connect the Model 263 to the IEEE-488 interface installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into the IBM interpretive BASIC language.
4. Enter the lines below using the return key after each line.
5. Run the program and type in the desired command string. For example, to place the instrument in the current function and 200μA range, type in F1R9X and press the return key.
6. The instrument reading string will then appear on the display.

PROGRAM	COMMENTS
`10 DEF SEG=&HC400`	' Memory address.
`20 INITIALIZE=0`	
`30 SEND=9: ENTER=21`	' Routine addresses.
`40 MY.ADDRESS%=21`	' PC < > 488 address.
`50 INST.ADDRESS%=8`	' 263 address.
`60 CONTROLLER%=0`	' System controller.
`70 CALL INITIALIZE(MY.ADDRESS%,CONTROLLER%)`	' Initialize system.
`80 INPUT ''ENTER COMMAND STRING'';CMD$`	' Prompt for string.
`90 CALL SEND(INST.ADDRESS%,CMD$,STATUS%)`	' Send command string.
`100 READING$=SPACE$(16)`	' Make room for data.
`110 CALL ENTER(READING$,LENGTH%,INST.ADDRESS%, STATUS%)`	' Get reading from 263.
`120 PRINT READING$`	' Display reading.
`130 GOTO 80`	' Repeat.
`140 END`	

NOTE: For conversion to numeric variable, make the following changes:

```
120 READNG=VAL(MID$(READING$,5,14))
125 PRINT READING
```

IBM PC OR AT (NATIONAL GPIB PC INTERFACE)

The following program sends a command string to the Model 263 from an IBM PC or AT computer and displays the instrument reading string on the CRT. The computer must be equipped with the National GPIB PC Interface and the DOS 2.00 (or later revision) operating system. Interface software must be installed and configured as described in the instruction manual.

DIRECTIONS

1. Using the front panel program feature, set the primary address of the Model 263 to 8.
2. With the power off, connect the Model 263 to the IEEE-488 interface installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into the IBM interpretive BASIC language.
4. Place the interface software disk in the default drive, type LOAD"DECL", and press the return key.
5. Add the lines below to lines 1-6 which are now in memory. Modify the address in lines 1 and 2, as described in the National instruction manual.
6. Run the program and type in the desired command string. For example, to place the instrument in the current function and 200μA range, type in F1R9X and press the return key.
7. The instrument reading string will then appear on the display.
8. To exit the program, type in EXIT at the command prompt and press the return key.

PROGRAM	COMMENTS
`10 CLS`	Clear screen.
`20 NA$="GPIB0":CALL IBFIND (NA$,BRD0%)`	Find board descriptor.
`30 NA$="DEV1":CALL IBFIND (NA$,M263%)`	Find instrument descriptor.
`40 V%=8:CALL IBPAD(M263%,V%)`	Set primary address to 8.
`50 V%=&H102:CALL IBPOKE(BRD0%,V%)`	Set timeouts.
`60 V%=1:CALL IBSRE(BRD0%,V%)`	Set REN true.
`70 INPUT"COMMAND STRING";CMD$`	Prompt for command.
`80 IF CMD$="EXIT" THEN 150`	See if program is to be halted.
`90 IF CMD$="" THEN 70`	Check for null input.
`100 CALL IBWRT(M263%,CMD$)`	Address 263 to listen, send string.
`110 RD$=SPACE$(100)`	Define reading input buffer.
`120 CALL IBRD(M263%,RD$)`	Address 263 to talk, get reading.
`130 PRINT RD$`	Display the string.
`140 GOTO 70`	Repeat.
`150 V%=0:CALL IBONL(M263%,V%)`	Close the instrument file.
`160 CALL IBONL(BRD0%, V%)`	Close the board file.
`170 END`	

NOTE: For conversion to numeric variable, make the following changes:

```
130 RD=VAL(MID$(RD$,5,14))
135 PRINT RD
```

APPLE II (APPLE II IEEE-488 INTERFACE)

The following program sends a command string to the Model 263 from an Apple II computer and displays the instrument reading string on the computer CRT.

The computer must be equipped with the Apple II IEEE-488 Interface installed in slot 3.

DIRECTIONS

1. Using the front panel program feature, set the primary address of the Model 263 to 8.
2. With the power off, connect the Model 263 to the IEEE-488 interface installed in the Apple II computer.
3. Enter the lines in the program below, using the RETURN key after each line.
4. Run the program and type in the desired command string at the command prompt. For example, to place the instrument in the current function and 200μA range, type in F1R9X and press the return key.
5. The instrument reading string will then appear on the CRT.

PROGRAM	COMMENTS
`10 Z$=CHR$(26)`	Terminator.
`20 INPUT"COMMAND STRING?";B$`	Prompt for and enter string.
`30 PR#3`	Set output to IEEE bus.
`40 IN#3`	Define input from IEEE bus.
`50 PRINT"RA"`	Enable remote.
`60 PRINT"WT(";Z$;B$`	Address 263 to listen, send string.
`70 PRINT"LF1"`	Line Feed on.
`80 PRINT"RDH";Z$;:INPUT" ";A$`	Address 263 to talk, input data.
`90 PRINT"UT"`	Untalk the 263.
`100 PR#0`	Define output to CRT.
`110 IN#0`	Define input from keyboard.
`120 PRINT A$`	Display reading string.
`130 GOTO 20`	Repeat.

NOTE:

If conversion to numeric variable is required, make the following changes:

```
120 A=VAL(MID$(A$,5,16))
125 PRINT A
```

HEWLETT-PACKARD MODEL 85

The following program sends a command string to the Model 263 from an HP-85 computer and displays the instrument reading string on the computer CRT. The computer must be equipped with the HP82937 GPIB Interface and an I/O ROM.

DIRECTIONS

1. Using the front panel program feature, set the primary address of the Model 263 to 8.
2. With the power off, connect the Model 263 to the HP82937A GPIB interface installed in the HP-85 computer.
3. Enter the lines in the program below, using the END LINE key after each line.
4. Press the HP-85 RUN key and type in the desired command string at the command prompt. For example, to place the instrument in the current function and 200μA range, type in F1R9X and press the END LINE key.
5. The instrument reading string will then appear on the CRT.

PROGRAM	COMMENTS
`10 DIM A$[40],B$[40]`	Dimension strings.
`20 REMOTE 708`	Place 263 in remote.
`30 DISP''COMMAND STRING'';`	Prompt for command.
`40 INPUT A$`	Input command string.
`50 OUTPUT 708; A$`	Address 263 to listen, send string.
`60 ENTER 708; B$`	Address 263 to talk, input reading.
`70 DISP B$`	Display reading string.
`80 GOTO 30`	Repeat
`90 END`	

NOTE: For conversion to numeric variable, change line 70 as follows:

```
70 DISP VAL(B$[5])
```

HEWLETT-PACKARD SERIES 300 and MODEL 9816

The following program sends a command string to the Model 263 from a Hewlett-Packard Series 300 or Model 9816 computer and displays the instrument reading string on the computer CRT. The computer must be equipped with the HP82937 GPIB Interface and BASICA 4.0.

DIRECTIONS

1. Using the front panel program feature, set the primary address of the Model 263 to 8.
2. With the power off, connect the Model 263 to the HP82937A GPIB interface installed in the computer.
3. Enter the lines in the program below, using the ENTER key after each line.
4. Press the RUN key and type in the desired command string at the command prompt. For example, to place the instrument in the current function and 200μA range, type in F1R9X and press the ENTER key.
5. The instrument reading string will then appear on the CRT.

PROGRAM	COMMENTS
`5 DIM B$[50]`	
`10 REMOTE 708`	Place 263 in remote.
`20 INPUT''COMMAND STRING'';A$`	Prompt for and input command.
`30 OUTPUT 708; A$`	Address 263 to listen, send string.
`40 ENTER 708; B$`	Address 263 to talk, input reading.
`50 PRINT B$`	Display reading string.
`60 GOTO 20`	Repeat.
`70 END`	

NOTE: For conversion to a numeric variable, change the program as follows:

```
40 ENTER 708;B
50 PRINT B
```

HEWLETT-PACKARD MODEL 9825A

Use the following program to send a command string to the Model 263 from a Hewlett-Packard Model 9825A and display the instrument reading string on the computer printer. The computer must be equipped with the HP98034A HPIB Interface and a 9872A extended I/O ROM.

DIRECTIONS

1. From the front panel, set the primary address of the Model 263 to 8.
2. With the power off, connect the Model 263 to the 98034A HPIB interface installed in the 9825A.
3. Enter the lines in the program below, using the STORE key after each line. Line numbers are automatically assigned by the 9825A.
4. Press the 9825A RUN key and type in the desired command string at the command prompt. For example, to place the instrument in the current function and 200μA range, type in F1R9X and press the CONT key.
5. The instrument reading string will then appear on the computer print out.

PROGRAM	COMMENTS
0 dim A$[25],B$[20]	Dimension data strings.
1 dev''263'',708	Define 263 at address 8.
2 rem''263''	Place 263 in remote.
3 ent''COMMAND STRING'',B$	Prompt for command string.
4 wrt''263'',B$	Address 263 to listen, send string.
5 red''263'',A$	Address 263 to talk, input data.
6 prt A$	Print data string on printer.
7 gto 3	Repeat.

NOTE: For conversion to numeric variable, modify the program as follows:

```
6 prt val(A$[5])
```

DEC LSI 11

The following program sends a command string to the Model 263 from a DEC LSI 11 minicomputer and displays the instrument reading string on the DEC CRT terminal. The LSI 11 must be configured with 16K words of RAM and an IBV 11 IEEE-488 interface. The software must be configured with the IB software as well as FORTRAN and the RT 11 operating system.

DIRECTIONS

1. Using the front panel program feature, set the primary address of the Model 263 to 8.
2. With the power off, connect the Model 263 to the IBV 11 IEEE-488 interface cable.
3. Enter the program below, using the editor under RT 11 and the name IEEE.FOR.
4. Compile using the FORTRAN compiler as follows: FORTRAN IEEE.
5. Link with the system and IB libraries as follows: LINK IEEE,IBLIB.
6. Type RUN IEEE and press the RETURN key.
7. The display will read "ENTER ADDRESS".
8. Type in 8 and press the RETURN key.
9. The display will read "TEST SETUP".
10. Type in the desired command string and press the RETURN key. For example, to program the instrument for the current function and 200μA range, type in F1R9X and press RETURN.
11. The instrument data string will appear on the computer display.

PROGRAM	COMMENTS
`  PROGRAM IEEE`	
`  INTEGER*2 PRIADR`	
`  LOGICAL*1 MSG(80),INPUT(80)`	
`  DO 2 I = 1,10`	
`  CALL IBSTER(I,0)`	Turn off IB errors.
`2 CONTINUE`	
`  CALL IBSTER(15,5)`	Allow 5 error 15's.
`  CALL IBTIMO(120)`	Allow 1 second bus timeout.
`  CALL IBTERM(10)`	Set line feed as terminator.
`  CALL IBREN`	Turn on remote.
`4 TYPE 5`	
`5 FORMAT (1X,'ENTER ADDRESS:',$)`	Input primary address.
`  ACCEPT 10,PRIADR`	
`10 FORMAT (I2)`	
`12 TYPE 15`	
`15 FORMAT (1X,'TEST SETUP:',$)`	Prompt for command string.
`  CALL GETSTR (5,MSG,72)`	Program instrument.
`  CALL IBSEOI (MSG,-1,PRIADR)`	Address 263 to listen, send string.
`18 I=IBRECV (INPUT,80,PRIADR)`	Get data from instrument.
`  INPUT (I+1) = 0`	
`  CALL PUTSTR (7,INPUT,'0')`	
`  CALL IBUNT`	Untalk the 263.
`  GOTO 12`	Repeat.
`  END`	

APPENDIX F

IEEE-488 Bus Overview

INTRODUCTION

Basically, the IEEE-488 bus is simply a communication system between two or more electronic devices. A device can be either an instrument or a computer. When a computer is used on the bus, it serves to supervise the communication exchange between all the devices and is known as the controller. Supervision by the controller consists of determining which device will talk and which devices will listen. As a talker, a device will output information and as a listener, a device will receive information. To simplify the task of keeping track of the devices, a unique address number is assigned to each one.

On the bus, only one device can talk at a time and is addressed to talk by the controller. The device that is talking is known as the active talker. The devices that need to listen to the talker are addressed to listen by the controller. Each listener is then referred to as an active listener. Devices that do not need to listen are instructed to unlisten. The reason for the unlisten instruction is to optimize the speed of bus information transfer since the task of listening takes up bus time.

Through the use of control lines, a handshake sequence takes place in the transfer process of information from a talker to a listener. This handshake sequence helps ensure the credibility of the information transfer. The basic handshake sequence between an active controller (talker) and a listener is as follows:

1. The listener indicates that it is ready to listen.
2. The talker places the byte of data on the bus and indicates that the data is available to the listener.
3. The listener, aware that the data is available, accepts the data and then indicates that the data has been accepted.
4. The talker, aware that the data has been accepted, stops sending data and indicates that data is not being sent.
5. The listener, aware that there is no data on the bus, indicates that it is ready for the next byte of data.

BUS DESCRIPTION

The IEEE-488 bus, which is also frequently referred to as the GPIB (General Purpose Interface Bus), was designed as a parallel transfer medium to optimize data transfer without using an excessive number of bus lines. In keeping with this goal, the bus has only eight data lines that are used for both data and with most commands. Five bus management lines and three handshake lines round out the complement of bus signal lines.

A typical set up for controlled operation is shown in Figure F-1. Generally, a system will contain one controller and a number of other instruments to which the commands are given. Device operation is categorized into three operators: controller, talker and listener. The controller does what its name implies; it controls the instruments on the bus. The talker sends data while a listener receives data. Depending on the type of instrument, any particular device can be a talker only, a listener only or both a talker and a listener.

There are two catagories of controllers: system controller, and basic controller. Both are able to control other instruments, but only the system controller has the absolute authority in the system. In a system with more than one controller, only one controller may be active at any given time. Certain protocol is used to pass control from one controller to another.

The IEEE-488 bus is limited to 15 devices, including the controller. Thus, any number of talkers and listeners up to that limit may be present on the bus at one time. Although several devices may be commanded to listen simultaneously, the bus can have only one active talker, or communications would be scrambled.

A device is placed in the talk or listen state by sending an appropriate talk or listen command. These talk and listen commands are derived from an instrument's primary ad-

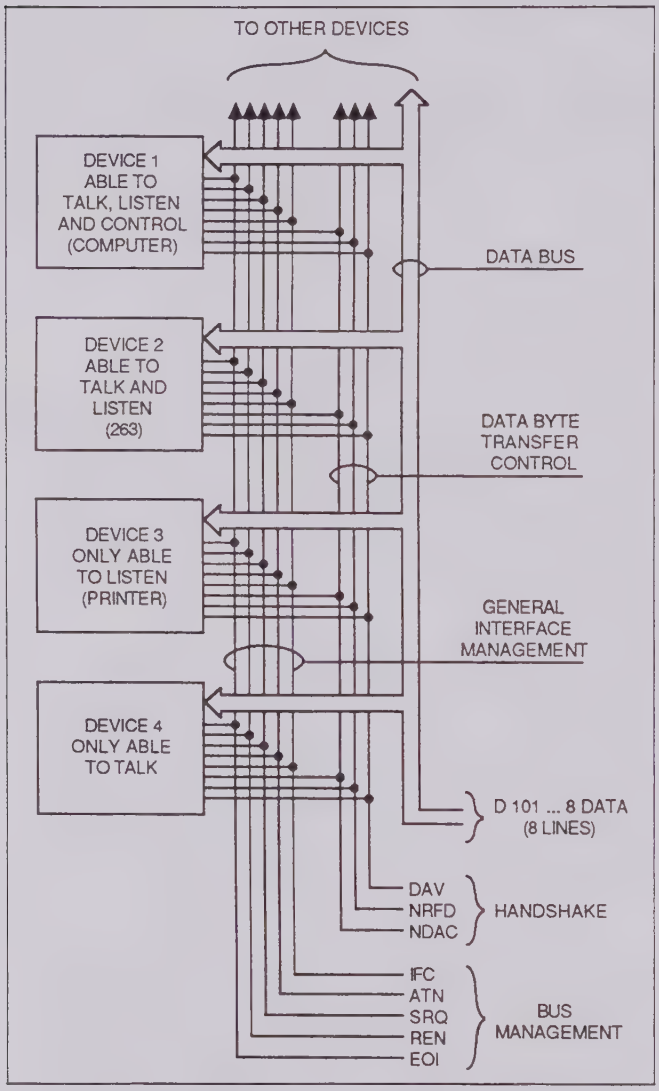


Figure F-1. IEEE Bus Configuration

dress. The primary address may have any value between 0 and 30, and is generally set by rear panel DIP switches or programmed in from the front panel of the instrument. The actual listen address value sent out over the bus is obtained by ORing the primary address with $20. For example, if the primary address is 8 ($08), the actual listen address is $28 ($28 = $08 + $20). In a similar manner, the talk address is obtained by ORing the primary address with $40. With the present example, the talk address derived from a primary address of 4 decimal would be $48 ($48 = $08 + $40).

The IEEE-488 standards also include another addressing mode called secondary addressing. Secondary addresses lie in the range of $60-$7F. Note, however that many devices, including the Model 263, do not use secondary addressing.

Once a device is addressed to talk or listen, the appropriate bus transactions take place. For example: if the instrument is addressed to talk, it places its data string on the bus one byte at a time. The controller reads the information and the appropriate software can be used to direct the information to the desired location.

BUS LINES

The signal lines on the IEEE-488 bus are grouped into three different categories: data lines, management lines and handshake lines. The data lines handle bus data and commands, while the management and handshake lines ensure that proper data transfer and operation takes place. Each bus line is active low, with approximately zero volts representing a logic 1 (true). The following paragraphs describe the operation of these lines.

Data Lines

The IEEE-488 bus uses eight data lines that transfer data one byte at a time. DIO1 (Data Input/Output) through DIO8 (Data Input/Output) are the eight data lines used to transmit both data and multiline commands and are bidirectional. The data lines operate with low true logic.

Bus Management Lines

The five bus management lines help to ensure proper interface control and management. These lines are used to send the uniline commands.

ATN (Attention)—The ATN line is one of the more important management lines in that the state of this line determines how information on the data bus is to be interpreted.

IFC (Interface Clear)—As the name implies, the IFC line controls clearing of instruments from the bus.

REN (Remote Enable)—The REN line is used to place the instrument on the bus in the remote mode.

EOI (End or Identify)—The EOI line is usually used to mark the end of a multi-byte data transfer sequence.

SRQ (Service Request)—This line is used by devices when they require service from the controller.

Handshake Lines

The bus uses handshake lines that operate in an interlocked sequence. This method ensures reliable data transmission regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the three handshake lines is controlled by the source (the talker sending information), while the remaining two lines are controlled by accepting devices (the listener or listeners receiving the information). The three handshake lines are:

DAV (Data Valid)—The source controls the state of the DAV line to indicate to any listening devices whether or not data bus information is valid.

NRFD (Not Ready For Data)—The acceptor controls the state of NRFD. It is used to signal to the transmitting device to hold off the byte transfer sequence until the accepting device is ready.

NDCA (Not Data Accepted)—NDCA is also controlled by the accepting device. The state of NDCA tells the source whether or not the device has accepted the data byte.

The complete handshake sequence for one data byte is shown in Figure F-2. Once data is placed on the data lines, the source checks to see that NRFD is high, indicating that all active devices are ready. At the same time, NDAC should be low from the previous byte transfer. If these conditions are not met, the source must wait until NDCA and NRFD have the correct status. If the source is a controller, NRFD and NDAC must by stable for at least 100nsec after ATN is set true. Because of the possibility of a bus hang up, many controllers have time-out routines that display messages in case the transfer sequence stops for any reason.

Once all NDAC and NRFD are properly set, the source sets DAV low, indicating to accepting devices that the byte on the data lines is now valid. NRFD will then go low, and NDAC will go high once all devices have accepted the data. Each device will release NDAC at its own rate, but NDAC will not be released to go high until all devices have accepted the data byte.

The sequence just described is used to transfer both data, talk and listen addresses, as well as multiline commands. The state of the ATN line determines whether the data bus contains data, addresses or commands as described in the following paragraph.

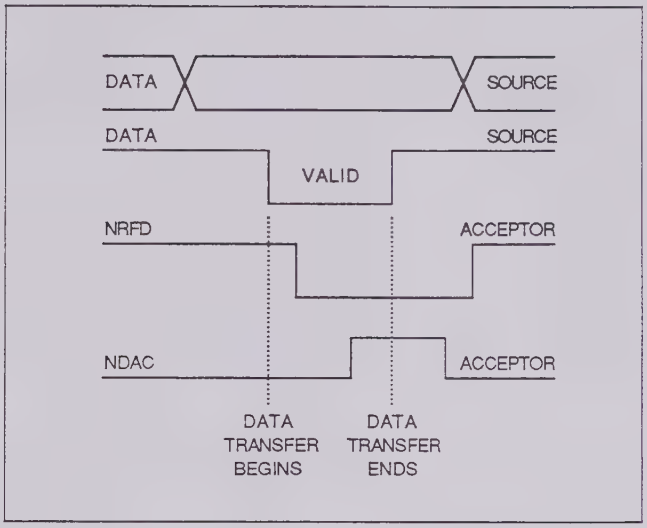


Figure F-2. IEEE-488 Handshake Sequence

BUS COMMANDS

The instrument may be given a number of special bus commands through the IEEE-488 interface. This section briefly describes the purpose of the bus commands which are grouped into the following three categories.

1. Uniline Commands - Sent by setting the associated bus lines true. For example, to assert REN (Remote Enable), the REN line would be set low (true).
2. Multiline Commands - General bus commands which are sent over the data lines with the ATN line true (low).
3. Device-Dependent Commands - Special commands whose meanings depend on device configurations; sent with ATN high (false).

These bus commands and their general purposes are summarized in Table F-1.

Uniline Commands

ATN, IFC and REN are asserted only by the controller. SRQ is asserted by an external device. EOI may be asserted either by the controller or other devices depending on the direction of data transfer. The following is a description of each command. Each command is sent by setting the corresponding bus line true.

Table F-1. IEEE-488 Bus Command Summary

Command Type	Command	ATN Line*	State of Comments
Uniline	REN (Remote Enable)	X	Sets up devices for remote operation.
	EOI	X	Marks end of transmission.
	IFC (Interface Clear)	X	Clears interface.
	ATN (Attention)	Low	Defines data bus contents.
	SRQ	X	Controlled by external device.
	Multiline		
Universal	LLO (Local Lockout)	Low	Locks out local operation.
	DCL (Device Clear)	Low	Returns device to default conditions.
	SPE (Serial Enable)	Low	Enables serial polling.
	SPD Serial Poll Disable)	Low	Disables serial polling.
Addressed	SDC (selective Device Clear)	Low	Returns unit to default conditions.
	GTL (Go To Local)	Low	Returns device to local.
Unaddressed	UNL (Unlisten)	Low	Removes all listeners from bus.
	UNT (Untalk)	Low	Removes any talkers from bus.
Device-dependent		High	Programs Model 595 for various modes.

*X = Don't Care.

REN (Remote Enable)—REN is sent to set up instruments on the bus for remote operation. When REN is true, devices will be removed from the local mode. Depending on device configuration, all front panel controls except the LOCAL button (if the device is do equiped) may be locked out when REN is true. Generally, REN should be sent before attempting to program instruments over the bus.

EOI (End Or Identify)—EOI is used to positively identify the last byte in a multi-byte transfer sequence, thus allowing data words of various lengths to be transmitted easily.

IFC (Interface Clear)—IFC is used to clear the interface and return all devices to the talker and listener idle states.

ATN (Attention)—The controller sends ATN while transmitting addresses or multiline commands.

SRQ (Service Request)—SRQ is asserted by a device when it requires service from a controller.

Universal Multiline Commands

Universal commands are those multiline commands that require no addressing. All devices equipped to implement such commands will do so simultaneously when the command is transmitted. As with all multiline commands, these commands are transmitted with ATN true.

LLO (Local Lockout)—LLO is sent to the instrument to lock out their front panel controls.

DCL (Device Clear)—DCL is used to return instruments to some default state. Usually, instruments return to their power-up conditions.

SPE (Serial Poll Enable)—SPE is the first step in the serial polling sequence, which is used to determine which device has requested service.

SPD (Serial Poll Disable)—SPD is used by the controller to remove all devices on the bus from the serial poll mode and is generally the last command in the serial polling sequence.

Addressed Multiline Commands

Addressed commands are multiline commands that must be preceded by the device listen address before that instrument will respond to the command in question. Note that only the addressed device will respond to these commands. Both the command and the address preceding it are sent with ATN true.

SDC (Selective Device Clear)—The SDC command performs essentially the same function as the DCL command except that only the addressed device responds. Generally, instruments return to their power-up default conditions when responding to the SDC command.

GTL (Go To Local)—The GTL command is used to remove instruments from the remote mode. With some instruments, GTL also unlocks front panel controls if they were previously locked out with the LLO command.

GET (Group Execute Trigger)—The GET command is used to trigger devices to perform a specific action that depends on device configuration (for example, take a reading). Although GET is an addressed command, many devices respond to GET without addressing.

Address Commands

Addressed commands include two primary command groups and a secondary address group. ATN is true when these commands are asserted. The commands include:

LAG (Listen Address Group)—These listen commands are derived from an instrument's primary address and are used to address devices to listen. The actual command byte is obtained by ORing the primary address with $20.

TAG (Talk Address Group)—The talk commands are derived from the primary address by ORing the address with $40. Talk commands are used to address devices to talk.

SCG (Secondary Command Group)—Commands in this group provide additional addressing capabilities. Many devices (including the Model 263) do not use these commands.

Unaddress Commands

The two unaddress commands are used by the controller to remove any talkers or listeners from the bus. ATN is true when these commands are asserted.

UNL (Unlisten)—Listeners are placed in the listener idle state by the UNL command.

UNT (Untalk)—Any previously commanded talkers will be placed in the talker idle state by the UNT command.

Device-Dependent Commands

The purpose of the device-dependent commands will depend on the configuration of the instrument. Generally, these commands are sent as one or more ASCII characters that tell the device to perform a specific function.

The IEEE-488 bus actually treats these commands as data in that ATN is false when the commands are transmitted.

Command Codes

Command codes for the various commands that use the data lines are summarized in Figure F-3. Hexadecimal and the decimal values for the various commands are listed in Table F-2.

Table F-2. Hexadecimal and Decimal Command Codes

Command	Hex Value	Decimal Value
GTL	01	1
SDC	04	4
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
SGG	60-7F	96-127
UNL	3F	63
UNT	5F	95

Typical Command Sequences

For the various multiline commands, a specific bus sequence must take place to properly send the command. In particular, the correct listen address must be sent to the instrument before it will respond to addressed commands. Table F-3 lists a typical bus sequence for sending the addressed multiline command. In this instance, the SDC command is being sent to the instrument. UNL is generally sent as part of the sequence to ensure that no other active listeners are present. Note that ATN is true for both the listen command and the SDC command byte itself.

Table F-4 gives a typical device-dependent command sequence. In this instance, ATN is true while the instrument is being addressed, but it is set high while sending the device-dependent command string.

IEEE Command Groups

Command groups supported by the Model 263 are listed in Table F-5. Device-dependent commands are not included in this list.

Table F-3. Typical Addressed Command Sequence

Step	Command	ATN State	Data Bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	(	28	40
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address = 8.

Table F-4. Typical Device-Dependent Command Sequence

Step	Command	ATN State	Data Bus		
			ASCII	Hex	Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	(	28	40
3	Data	Set high	F	52	82
4	Data	Stays high	0	30	48
5	Data	Stays high	X	58	88

*Assumes primary address = 8.

Table F-5. IEEE Command Group

HANDSHAKE COMMAND GROUP
DAC=DATA ACCEPTED
RFD=READY FOR DATA
DAV=DATA VALID
UNIVERSAL COMMAND GROUP
ATN=ATTENTION
DCL=DEVICE CLEAR
IFC=INTERFACE CLEAR
LLO=LOCAL LOCKOUT
REN=REMOTE ENABLE
SPD=SERIAL POLL DISABL
SPE=SERIAL POLL ENABLE
ADDRESS COMMAND GROUP
LISTEN: LAG=LISTEN ADDRESS GROUP
MLA=MY LISTEN ADDRESS
UNL=UNLISTEN
TALK: TAG=TALK ADDRESS GROUP
MTA=MY TALK ADDRESS
UNT=UNTALK
OTA=OTHER TALK ADDRESS
ADDRESSED COMMAND GROUP
ACG=ADDRESSED COMMAND GROUP
GTL=GO TO LOCAL
SDC=SELECTIVE CLEAR
STATUS COMMAND GROUP
RQS=REQUEST SERVICE
SRQ=SERIAL POLL REQUEST
STB=STATUS BYTE
EOI=END

D_7 D_6 D_5 D_4					X 0 0 0		X 0 0 1		X 0 1 0		X 0 1 1		X 1 0 0		X 1 0 1		X 1 1 0		X 1 1 1	
BITS D_3 ↓	D_2 ↓	D_1 ↓	D_0 ↓	COLUMN-- ROW↓	0(A)	0(B)	1(A)	1(B)	2(A)	2(B)	3(A)	3(B)	4(A)	4(B)	5(A)	5(B)	6(A)	6(B)	7(A)	7(B)
0	0	0	0	0	NUL		DLE		SP	0	0	16	@	O	P	16			p	
0	0	0	1	1	SOH	GTL	DC1	LLO	!	1	1	17	A	1	Q	17	a		q	
0	0	1	0	2	STX		DC2		"	2	2	18	B	2	R	18	b		r	
0	0	1	1	3	ETX		DC3		#	3	3	19	C	3	S	19	c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$	4	4	20	D	4	T	20	d		t	
0	1	0	0	5	ENQ	PPC*	NAK	PPU*	%	5	5	21	E	5	U	21	e		u	
0	1	1	0	6	ACK		SYN		&	6	6	22	F	6	V	22	f		v	
0	1	1	1	7	BEL		ETB		'	7	7	23	G	7	W	23	g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(	8	8	24	H	8	X	24	h		x	
1	0	0	1	9	HT	TCT*	EM	SPD	)	9	9	25	I	9	Y	25	i		y	
1	0	1	0	10	LF		SUB		*	10	:	26	J	10	Z	26	j		z	
1	0	1	1	11	VT		ESC		+	11	;	27	K	11	[	27	k		{	
1	1	0	0	12	FF		FS		,	12	<	28	L	12	\	28	l		:	
1	1	0	1	13	CR		GS		-	13	=	29	M	13	]	29	m		}	
1	1	1	0	14	SO		RS		.	14	>	30	N	14	∩	30	n		~	
1	1	1	1	15	SI		US		/	15	?	UNL	O	15	—	UNT	o		DEL	

ADDRESSED COMMAND GROUP (ACG)

UNIVERSAL COMMAND GROUP (UCG)

LISTEN ADDRESS GROUP (LAG)

TALK ADDRESS GROUP (TAG)

PRIMARY COMMAND GROUP (PCG)

SECONDARY COMMAND GROUP SDC)

*PPC (PARALLEL POLL CONFIGURE). PPU (PARALLEL POLL UNCONFIGURE), AND TCT (TAKE CONTROL) NOT IMPLEMENTED BY MODEL 263.

NOTE: D_0 = DIO1 ... D_7 = DIO8
X = DON'T CARE

Figure F-3. Command Codes

APPENDIX G

Performance Verification and Calibration Records

Performance Verification Record

The tables in this record are the same tables used in the performance verification section but are grouped together so that they can be filed easily. Make copies of this document and follow the performance verification procedure in Section 6.

Date:

Serial Number:

Table 6-2. VOLTS Accuracy Checks

263 Range	263 Programmed Output	196 Range	Allowable 196 Reading (18°C to 28°C)	196 Reading
200mV	00.000mV	300mV	−00.0150 to 00.0150	_____
200mV	±20.000mV	300mV	±19.9835 to ±20.0175	+ _____
				− _____
200mV	±100.000mV	300mV	±99.9725 to ±100.0275	+ _____
				− _____
200mV	±190.000mV	300mV	±189.9613 to ±190.0387	+ _____
				− _____
2 V	.00000 V	3 V	−.000050 to .000050	_____
2 V	±.20000 V	3 V	±.199925 to ±.200075	+ _____
				− _____
2 V	±1.00000 V	3 V	±.999825 to ±.000175.	+ _____
				− _____
2 V	±1.90000 V	3 V	±1.899713 to ±1.900287	+ _____
				− _____
20 V	0.0000 V	30 V	−0.00050 to ±0.00050	_____
20 V	±2.0000 V	30 V	±1.99925 to ±2.00075	+ _____
				− _____
20 V	±10.0000 V	30 V	±9.99825 to ±10.00175	+ _____
				− _____
20 V	±19.0000 V	30 V	±18.99713 to ±19.00287	+ _____
				− _____

Table 6-3. 1kΩ Accuracy Checks

263 Range	263 Programmed Output	196 Range	Allowable 196 Reading (18°C to 28°C)	196 Reading
1kΩ	.00000kΩ	3kΩ	<1Ω Zero offset	_____
1kΩ	1.00____kΩ	3kΩ	_____ to _____ (±0.04% × PO*) + PO*	_____

*PO = Programmed Output

Table 6-4. AMPS Zero Offset Checks

263 Range	263 Programmed Output	617 Range	Allowable 617 Reading (18°C to 28°C)	617 Reading
2 pA	.00000pA	2pA	−.1000 to .1000	_____
20 pA	0.0000pA	2pA	−.1000 to .1000	_____
200 pA	00.000pA	2pA	−.1200 to .1200	_____
2 nA	.00000nA	20pA	−0.200 to 0.200	_____
20 nA	0.0000nA	200pA	−01.00 to 01.00	_____
200 nA	00.000nA	2nA	−.0100 to .0100	_____
2 μA	.00000 μA	20nA	−0.100 to 0.100	_____
20 μA	0.0000 μA	200nA	−01.00 to 01.00	_____
200 μA	00.000 μA	2 μA	−.0100 to .0100	_____
2mA	.00000mA	20 μA	−0.100 to 0.100	_____
20mA	0.0000mA	200 μA	−01.00 to 01.00	_____

Table 6-5. AMPS (200μA-2mA) Accuracy Checks

263 Range	263 Programmed Output	196 Range	5450A Resistor (Nominal)	Setup (Figure)	Calculated Output Current 196 Reading ÷ 5450A Reading = Current	Allowable Calculated Current (18°C to 28°C)
20 μA	10.0000μA	3 V	100 kΩ	6-3	_____ ÷ _____ = _____	9.9965μA to 10.0035μA
20 μA	−10.0000μA	3 V	100 kΩ	6-3	_____ ÷ _____ = _____	−9.9965μA to −10.0035μA
20 μA	19.0000μA	3 V	100 kΩ	6-3	_____ ÷ _____ = _____	18.9943μA to −19.0057μA
20 μA	−19.0000μA	3 V	100 kΩ	6-3	_____ ÷ _____ = _____	−18.9943μA to −19.0057μA
200 μA	190.000μA	3 V	10 kΩ	6-4	_____ ÷ _____ = _____	189.943μA to 190.057μA
2mA	1.90000mA	3 V	1 kΩ	6-4	_____ ÷ _____ = _____	1.89943mA to 1.90057mA

Table 6-6. AMPS (20pA-2μA) Accuracy Checks

263 Range	263 Programmed Output	196 Range	5450A Resistor (Nominal)	196 Reading	Calculated Output Current 196 Avg.*÷5450A Reading=Current	Allowable Calculated Current (18°C to 28°C)
20pA	19.0000pA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	18.9383pA to 19.0617pA
20pA	−19.0000pA	300mV	100MΩ	− _____		
200pA	190.000pA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	189.620pA to 190.380pA
200pA	−190.000pA	300mV	100MΩ	− _____		
2nA	1.90000nA	300mV	100MΩ	+ _____	_____ ÷ _____ = _____	1.89882nA to 1.90118nA
2nA	−1.90000nA	300mV	100MΩ	− _____		
20nA	19.0000nA	3 V	100MΩ	+ _____	_____ ÷ _____ = _____	18.9882nA to 19.0118nA
20nA	−19.0000nA	3 V	100MΩ	− _____		
200nA	190.000nA	3 V	10MΩ	+ _____	_____ ÷ _____ = _____	189.934nA to 190.066nA
200nA	−190.000nA	3 V	10MΩ	− _____		
2 μA	1.90000 μA	3 V	1MΩ	+ _____	_____ ÷ _____ = _____	1.89953 μA to 1.90047 μA
2 μA	−1.90000 μA	3 V	1MΩ	− _____		

*The average 196 reading is calculated by adding the absolute values of the positive and negative readings, and dividing by two.

Table 6-7. AMPS V/R Functional Checks

263 Range	263 Programmed Output	617 Range	Allowable 617 Reading* (18°C to 28°C)	617 Reading
200pA	190.000pA	200pA	186.95 to 193.05	_____
200 μA	190.000 μA	200 μA	189.71 to 190.29	_____

*Reading limits determine by the accuracy specifications of the Model 617.

Calibration Record

The tables in this record are the same tables used in the calibration section but are grouped together so that they can be filed easily. Make copies of this document and follow the calibration procedure in Section 8.

Date:

Serial Number:

Table 8-3. "Cold" Volts Calibration

DMM Range	263 Programmed Output	Actual Voltage Output (DMM Reading)	263 Calibration Value
300mV	190.000mV	____.____mV	____.____mV
3 V	1.90000V	_._____ V	_._____ V
30 V	19.0000V	__.____ V	__.____ V

Table 8-4. "Cold" Low Ohms Calibration

DMM Range	263 Range	263 Calibration Value (DMM Reading)
3 kΩ	1 kΩ	_._____ kΩ
30 kΩ	10 kΩ	__.____ kΩ
300 kΩ	100 kΩ	____.___ kΩ
3MΩ	1MΩ	_._____MΩ

Table 8-5. "Cold" High Ohms Calibration

DMM Range	263 "Ladder" Range	Actual Voltage Output (DMM Reading)	263 Calibration Value
30 V	1.00000ML	___._____ V	_._____ML
30 V	10.0000ML	___._____ V	__._____ML
3 V	100.000ML	_._____ V	____.____ML
300mV	1.00000GL	____.____mV	_._____GL
3 V	10.0000GL	_._____ V	__._____GL
300mV	100.000GL	____.____mV	____.____GL

Table 8-6. "Hot" Volts Calibration

DMM Range	263 Programmed Output	Actual Voltage Output (DMM Reading)	263 Calibration Value
300mV	190.000mV	____.____mV	____.____mV
3 V	1.90000V	_._____ V	_._____ V
30 V	19.0000V	__._____ V	__._____ V

Table 8-7. "Hot" Low Ohms Calibration

DMM Range	263 Range	263 Calibration Value (DMM Reading)
3 kΩ	1 kΩ	_._____ kΩ
30 kΩ	10 kΩ	__._____ kΩ
300 kΩ	100 kΩ	____.____ kΩ
3MΩ	1MΩ	_._____MΩ

Table 8-8. "Hot" High Ohms Calibration

DMM Range	263 "Ladder" Range	Actual Voltage Output (DMM Reading)	263 Calibration Value
30 V	1.00000ML	___._____ V	_._____ML
30 V	10.0000ML	___._____ V	___._____ML
3 V	100.000ML	_._____ V	____.____ML
300mV	1.00000GL	____.____mV	_._____GL
3 V	10.0000GL	_._____ V	___._____GL
300mV	100.000GL	____.____mV	____.____GL

Table 8-9. "Cold" High Ohms Calibration (Direct Measurement Method)*

263 Range	263 Guard	Measured Resistance (Calibration Value)
10MΩ	OFF	___._____MΩ
100MΩ	ON	____.____MΩ
1GΩ	ON	_._____GΩ
10GΩ	ON	___._____GΩ
100GΩ	ON	____.____GΩ

*Do not use this table if the "ladder" technique is used to calibrate the 10MΩ through 100GΩ ranges.

Table 8-10. "Hot" High Ohms Calibration (Direct Measurement Method)*

263 Range	263 Guard	Measured Resistance (Calibration Value)
10MΩ	OFF	__._____MΩ
100MΩ	ON	____.___MΩ
1GΩ	ON	_._____GΩ
10GΩ	ON	__._____GΩ
100GΩ	ON	____.___GΩ

*Do not use this table if the "ladder" technique is used to calibrate the 10MΩ through 100GΩ ranges.

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Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

- ❑ Intermittent
- ❑ Analog output follows display
- ❑ Particular range or function bad; specify _____
- ❑ IEEE failure
- ❑ Obvious problem on power-up
- ❑ Batteries and fuses are OK
- ❑ Front panel operational
- ❑ All ranges or functions are bad
- ❑ Checked all cables

Display or output (check one)

- ❑ Drifts
- ❑ Unstable
- ❑ Overload
- ❑ Unable to zero
- ❑ Will not read applied input

- ❑ Calibration only
- ❑ Data required
- ❑ Certificate of calibration required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

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